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# EVALUATION OF ACUTE AND CHRONIC TOXICITY OF ONTARIO SEWAGE TREATMENT PLANT EFFLUENTS

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# EVALUATION OF ACUTE AND CHRONIC TOXICITY OF ONTARIO SEWAGE TREATMENT PLANT EFFLUENTS

Report prepared for:

MISA Municipal Section
Ontario Ministry of the Environment

Report prepared by:

Patricia L. Orr and Gordon R. Craig
Beak Consultants Limited, Brampton, Ontario
and
Stephen G. Nutt
XCG Consultants Ltd., Kitchener, Ontario
and
Joseph Stephenson
$CH_2M$ Hill Engineering Ltd., Waterloo, Ontario

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# EXECUTIVE SUMMARY

## Study Design

The assessment of lethal and sublethal effluent toxicity from ten Ontario sewage treatment plants (STPs) was conducted during both summer and winter operating conditions. Four 24-hour composite samples were collected from each plant per season. Three to six grab samples were also collected at five STPs in each season for comparison to composite samples.

Total residual chlorine (TRC) and total ammonia levels were measured immediately after sample collection and again after arrival at the toxicity laboratory. If sample TRC measured 0.1 mg/L or greater at the toxicity laboratory, a portion of the sample was dechlorinated. Acute lethality tests using rainbow trout and Daphnia magna were begun the same day on all composite and grab samples (both as-received and dechlorinated).

Chronic fathead minnow survival and growth tests and Ceriodaphnia dubia survival and reproduction tests were initiated the next day; of samples which were dechlorinated, only the dechlorinated portions was tested for chronic toxicity in order to assess toxic effects constituents other than TRC. Some samples were also adjusted to pH 6 prior to chronic test initiation (if un-ionized ammonia was 0.1 mg/L or more and 20% mortality was observed after a 24-hour exposure in trout tests) in order to reduce the un-ionized ammonia concentration of the sample below concentrations likely to cause acute lethality.

Effluents were chemically analyzed and data compared to toxicity results to identify potential toxicants. Subsamples were collected at the toxicity laboratory and submitted to the MOE for analysis of conventional parameters and metals. Selected samples were also analyzed for a range of organic chemicals.

## Acute Toxicity

Of a total of 123 grab and composite samples collected, 56% were acutely lethal to trout when tested as received. Only one of the ten STPs (Walkerton) produced effluent which was consistently non-lethal to trout during both summer and winter conditions. Forty-three samples contained 0.1 mg TRC/L on arrival at the toxicity laboratory and were therefore split for dechlorination. Of these, 33 (77%) were lethal to trout prior to dechlorination, while 18 (42%) were lethal after dechlorination (see also Section 5.6).

Only 34 samples (27%), tested as received, were lethal to Daphnia magna. Four STPs (Lindsay, Perth, Stratford, Walkerton) produced effluents which were consistently non-lethal to D. magna. Of samples split for dechlorination, only 8 (18%) were lethal after dechlorination, compared to 28 (64%) which were lethal prior to dechlorination.

### Chronic/Sublethal Toxicity

Only a small percentage of the eighty composite samples tested were lethal to fathead minnow larvae (17% samples) and C. dubia (31%) after 7 days of exposure, probably as a result of pre-treatment of some samples (dechlorination, pH-adjustment) to reduce TRC and un-ionized ammonia levels below concentrations expected to cause acute lethality. However, 69% of those samples caused reduced growth of fathead minnow larvae and 56% (45 samples) impaired reproduction among C. dubia. At least one sample from each STP caused sublethal effects on fathead minnow larvae and C. dubia, although it was not necessarily the same sample which affected both species.

Despite the fact that only samples with reduced TRC and un-ionized ammonia were tested for sublethal toxicity, the sublethal end-points (e.g., growth, reproduction) of the C. dubia and fathead minnow tests were a more sensitive measure of effluent toxicity than lethality. Therefore, sublethal tests could be used for more stringent (protective) control of effluent quality.

### Comparison of Species and Test Sensivity

Aquatic organisms are not equally sensitive to individual chemicals. Therefore, when exposed to the complex mixture of chemicals contained in an STP effluent sample, different test species may be expected to respond differently. Although a greater proportion of STP effluent samples were acutely lethal to rainbow trout (52% of all tests conducted on as-received and dechlorinated samples) compared to Daphnia magna (23%), neither species was consistently more sensitive to individual samples. Similarly, sublethal effluent toxicity to any given samples was not consistently greater for fathead minnows compared to Ceriodaphnia dubia, or vice versa. Consequently, effluent monitoring performed using only a single test species will not necessarily reflect the toxicity to other aquatic species.

### Effect of Effluent Sampling Procedure on Toxicity Test Results

There was no statistically significant difference between acute rainbow trout LC50 distributions of grab versus composite samples collected from the ten STPs. Although firm conclusions were not possible for Daphnia magna, due to the small number of acutely lethal samples, there did not subjectively appear to be a difference in LC50 distribution which could be ascribed to differences in sampling procedure. Results of toxicity tests conducted on grab samples (both species) agreed more than 77% of the time in summer and more than 95% of the time in winter with results based on corresponding composite samples in differentiating between a lethal and non-lethal effluent.

### Effect of Industrial Loading on Effluent Toxicity

The influence of industrial loading on effluent toxicity was assessed based on a subjective rating of the industrial loading to each STP and a small number of STPs in each category. Based on the limited number of STPs in each of the industrial loading categories, rainbow trout acute lethality data suggested a trend toward less toxic effluent at STPs classified as having a "low" industrial load contribution. However, the differences were not significant at the 95% confidence level. Daphnia magna acute toxicity test data did not support detailed analysis because of the low number of lethal samples. The results of the C. dubia test showed a trend toward greater chronic effect as the industrial plant load increased. The differences in C. dubia toxicity of effluents from STPs categorized as receiving a "low" industrial load compared to those categorized as receiving a "high" industrial load were significant. Chronic fathead minnow tests could not identify a statistically significant difference in effluent toxicity related to industrial wastewater loading.

### Effect of STP Operating Conditions on Effluent Sample Toxicity

Effluent samples collected under cold weather operating conditions exhibited more acute toxicity (i.e., lower LC50 distribution) to rainbow trout than samples collected from the same STPs under warm weather conditions. This trend was largely the result of elevated un-ionized ammonia concentrations in winter samples from four of the ten STPs. Although summer samples were more frequently lethal to Daphnia magna than winter samples, no statistically supportable conclusions could be drawn regarding seasonal effects due to the low number of acutely lethal samples.

Samples collected under cold weather conditions resulted in more chronic toxicity to Ceriodaphnia dubia, but this trend could not be attributed to seasonal differences in any single parameter relating to effluent processes. There was no significant difference in chronic toxicity of effluents to fathead minnows in summer vs. winter.

Lagoon effluent samples collected in cold weather conditions were more toxic in terms of both acute and chronic test results than those collected in warm weather conditions, and seemed to be associated with elevated sulphide and/or un-ionized ammonia concentrations in winter.

No statistically significant differences in acute or chronic toxicity could be related to plant process type (i.e., secondary, tertiary, or lagoon).

STP operation at less than 80 percent of the rated hydraulic capacity of the facility did not significantly affect the acute or chronic toxicity of plant effluent compared to operation near or above the rated plant capacity based on these data.

Conclusive effects of other operating conditions in secondary STPs (F/M ratio, SRT, aeration basin HRT) on the acute or chronic toxicity of the STP effluent are difficult to define due to the limited database (six STPs) and possible influences of other uncontrolled variables. These data suggest that effluents from plants operating with an aeration basin HRT longer than six hours are less toxic to trout than those with HRT greater than six hours. However, the data also suggest that effluents from plants operated at higher organic loadings had less sublethal effect on fathead minnow and C. dubia than plants with lower organic loading. Further controlled experimentation would be needed to confirm these findings.

### Contaminants Associated With Toxicity

Multiple regression analysis was the procedure used to identify the relative contribution of specific toxicants in STP effluent samples. In general, concentrations of conventional parameters and metals accounted for less than 60% of the variability observed in toxicity test results. Potential explanations for this include the following:

- Since the relative importance of many toxicants varies between STPs the analyses would not be expected to identify chemicals which contributed to toxicity in only a few STP effluents.
- The chemical concentrations used in the analyses were those measured in samples collected at the beginning of each toxicity test. Since the concentration of some chemicals changed during tests (eg., nitrogen species), the results of some toxicity tests may not have reflected initial chemical concentrations. Consequently, the ability of regression analyses to identify chemical concentration-toxicity relationships would be decreased.
- Complex phenomena such as potential toxicant interactions could not be evaluated within the scope of this study.

The second type of analysis performed involved the comparison of measured effluent chemical concentrations to their corresponding toxic concentrations as documented in the literature. While this approach also identified a number of potential or probable toxicants in the STP effluents, definitive conclusions were not possible. One explanation for this is that the toxic concentrations of each chemical documented in the literature represent only estimates, since the potency of many toxicants may be altered by other constituents in solution (e.g., Ca and Mg (hardness, alkalinity), hydrogen ions (pH), other toxicants). In addition, the latter two of the three points presented above likely apply.

In spite of the above limitations, there was evidence of toxic contribution of specific chemicals measured in this study.

Chlorinated effluents were more lethal to rainbow trout and Daphnia magna than dechlorinated effluents. TRC concentrations measured in effluent samples at the time of arrival at the toxicity laboratory were negatively correlated with LC50. TRC was, therefore, identified as one of the most important chemical parameters in determining effluent lethality in acute tests, and samples with initial TRC concentrations of about 0.2 mg/L or more were usually lethal to trout and D. magna. (The potential effects of TRC on chronic toxicity were not evaluated in this study.)

Un-ionized ammonia was also identified as an important toxicant, with samples containing initial concentrations above approximately 0.1 mg/L often being lethal to trout. Ammonia was also an important toxicant in chronic fathead minnow and C. dubia tests, even though sample pH was reduced in some tests to reduce the amount of ammonia present in the un-ionized (more toxic) form.

Concentrations of non-specific parameters such as BOD, dissolved organic carbon, and suspended solids appeared to be related to some of the variability observed in toxicity test results. That $BOD_5$ and DOC were frequently negatively correlated with toxicity test end-points (e.g., LC50, Ch.V.), particularly in fish tests, suggested that organic contaminants may have contributed to effluent toxicity. None of the specific organic contaminants measured in selected effluent samples, however, could be conclusively related to observed toxicity.

Elevated sulphide levels in lagoon samples were associated with increased toxicity in both acute and chronic tests.

Metals appeared to be associated with the toxicity of some effluent samples, particularly in acute tests with Daphnia magna, and in chronic tests. Conclusive evaluation of metal toxicity was confounded by potential interactions between any given metal and other effluent constituents (including other metals).

## Factors Affecting Assessment of Effluent Toxicity

Chemical analyses of total ammonia and residual chlorine conducted in the field at the time of sample collection and again after immediate delivery of the samples to the toxicity laboratory showed decreases in the concentrations of both parameters during transportation.

Changes in physical/chemical properties of effluent samples which occur during toxicity testing (e.g., nitrogen speciation, pH), may affect the outcome of toxicity test results.

Generally less than 50% of the observed variation in toxicity test data could be explained by variations in measured chemical concentrations. Interpretation of all toxicity test results in terms of chemical levels involved evaluation of the toxicity of each contaminant independent of other contaminants. The effects of additive, synergistic, or antagonistic interactions among contaminants could not be addressed in this study, but such factors likely account for some toxicity that could not be attributed to individual contaminants.

Recommendations for future Ontario STP effluent toxicity testing programs include:

- more than one species should be used for effluent toxicity monitoring programs;
- collection of samples by the grab technique will be adequate for most effluent lethality monitoring programs;
- monitoring programs should include sample collection during both summer and winter;
- initial efforts to reduce effluent lethality should focus on reductions in chlorine and ammonia concentrations;
- once effluent lethality is improved, efforts should be directed towards reduction of chronic/sublethal effluent toxicity;
- additional research is necessary to definitively identify STP operating conditions that affect effluent toxicity; and
- programs such as the Toxicity Identification/Reduction Evaluation developed by the U.S. EPA should be utilized in an attempt to identify specific effluent toxicants.

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## TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

ACKNOWLEDGEMENTS viii

LIST OF TABLES xiii

LIST OF FIGURES xv

GLOSSARY OF TERMS AND ABBREVIATIONS xviii

1.0 INTRODUCTION 1
- 1.1 Background (Phase I) 1
- 1.2 Objectives - Phase II 2
- 1.3 Overview of Project Scope 3

2.0 STUDY DESIGN AND METHODOLOGY 4
- 2.1 Site Selection 4
- 2.2 Sampling Schedule 7
- 2.3 Pre-Sampling Monitoring 7
- 2.4 Sample Collection and Transport 12
  - 2.4.1 Composite Samples 12
  - 2.4.2 Grab Samples 13
  - 2.4.3 Sample Transport 13
- 2.5 Sample Testing 13
  - 2.5.1 Analytical Chemistry 13
    - 2.5.1.1 On-Site Analytical Testing 16
    - 2.5.1.2 Analytical Testing at the Toxicity Laboratory 16
    - 2.5.1.3 Analysis of Conventionals, Metals and Organics (MOE) 17
    - 2.5.1.4 Sulphide Analysis 17
  - 2.5.2 Toxicity Tests 17

Page

2.5.3 Decision Points in Study Design 20
    2.5.3.1 Residual Chlorine 20
    2.5.3.2 Un-Ionized Ammonia 20
    2.5.3.3 Organics 21

3.0 TEST RESULTS 22
3.1 Toxicity Tests 22
3.1.1 Acute Lethal Toxicity 22
    3.1.1.1 Rainbow Trout 22
    3.1.1.2 Daphnia magna 22
3.1.2 Chronic Toxicity 33
    3.1.2.1 Fathead Minnow Larval Survival and Growth Impairment 33
    3.1.2.2 Ceriodaphnia dubia Survival and Reproduction Impairment 39
3.2 Effluent Chemistry 39
3.2.1 Summer Samples 39
3.2.2 Winter Samples 46

4.0 ANALYSIS AND INTERPRETATION OF TOXICITY TEST RESULTS 50
4.1 Effect of STP Operating and Design Conditions 50
4.1.1 Data Analysis 50
4.1.2 Sampling Procedures 51
4.1.3 Seasonal Effects 56
    4.1.3.1 Acute Toxicity 56
    4.1.3.2 Chronic Toxicity 58
4.1.4 Effect of Plant Type 58
    4.1.4.1 Acute Toxicity 58
    4.1.4.2 Chronic Toxicity 62
4.1.5 Effect of Industrial Wastewater Contribution 62
    4.1.5.1 Acute Toxicity 66
    4.1.5.2 Chronic Toxicity 66

Page

4.1.6 Effect of Operational Conditions 70
- 4.1.6.1 Acute Toxicity 72
- 4.1.6.2 Chronic Toxicity 72

4.2 Changes in Effluent Chemistry 81
- 4.2.1 During Sample Transport 81
- 4.2.2 During Toxicity Testing 89

4.3 Inter-Species Toxicity Comparison 99
- 4.3.1 Rainbow Trout and _Daphnia magna_ 99
- 4.3.2 Fathead Minnow and _Ceriodaphnia dubia_ 99
- 4.3.3 Implications 99

4.4 Principal Toxicants 99
- 4.4.1 Correlation and Regression Analyses 99
- 4.4.2 Comparison to Documented Toxic Concentrations 104
- 4.4.3 Rainbow Trout 105
  - 4.4.3.1 Regression Analyses 105
  - 4.4.3.2 Parameter-Specific Evaluation 107
  - 4.4.3.3 Summary 113
- 4.4.4 _Daphnia magna_ 114
  - 4.4.4.1 Regression Analyses 114
  - 4.4.4.2 Parameter-Specific Evaluation 114
  - 4.4.4.3 Summary 119
- 4.4.5 Fathead Minnow 119
  - 4.4.5.1 Regression Analyses 119
  - 4.4.5.2 Parameter-Specific Evaluation 121
  - 4.4.5.3 Summary 125
- 4.4.6 _Ceriodaphnia dubia_ 125
  - 4.4.6.1 Regression Analyses 125
  - 4.4.6.2 Parameter-Specific Evaluation 125
  - 4.4.6.3 Summary 130
- 4.4.7 Overview of Effluent Toxicants 130
  - 4.4.7.1 Chlorine 130
  - 4.4.7.2 Ammonia 130

Page

4.4.7.3 Sulphide 130
4.4.7.4 Metals 131
4.4.7.5 Organic Contaminants 131
4.5 Validity of Decision Points in Study Design 133
4.6 Quality of Data 134
4.6.1 Toxicity Tests 134
4.6.2 Chemical Analyses 135

5.0 SUMMARY AND CONCLUSIONS 136
5.1 Toxicity of Ontario STP Effluents 136
5.2 Comparison of Species and Test Sensitivity 137
5.3 Effect of Effluent Sampling Procedure on Toxicity Test Results 137
5.4 Effect of Industrial Loading on Effluent Toxicity 137
5.5 Effect of STP Operating Conditions on Effluent Sample Toxicity 138
5.6 Contaminants Associated with Toxicity 139
5.7 Factors Affecting Assessment of Effluent Toxicity 141

6.0 RECOMMENDATIONS 142

7.0 REFERENCES 144

APPENDIX A: Description of STPs and Sampling Locations 149
APPENDIX B: Toxicity Test Methods 197
APPENDIX C: Quality Assurance/Quality Control 211
APPENDIX D: Toxicity of Effluent Parameters to Test Organisms 228
APPENDIX E: Toxicity Test Results 237
APPENDIX F: Effluent Chemistry 248

## LIST OF TABLES

Page

Table No.

2.1: List of Candidate STPs for Full-Scale Effluent Toxicity Monitoring Program 6

2.2: Description of STPs Included in Sampling Program 8

2.3: STP Sampling Schedule 10

2.4: Schedule of Grab Samples 11

2.5: Analytical Parameters Measured in STP Effluent Samples 18

3.1: Summary of Toxicity Test Results - Cold Weather Conditions 23

3.2: Summary of Toxicity Test Results - Warm Weather Conditions 26

3.3: Percent Acutely Lethal STP Effluent Samples 29

3.4: Samples Which Produced Chronic Lethal or Sublethal Effects on Fathead Minnows or *C. dubia* 38

3.5: Average Concentrations of Conventional Contaminants and Metals in Composite Samples of Effluents During Summer Sampling Program 43

3.6: Concentrations of Trace Organic Compounds Detected in Effluent Samples, Summer Sampling Program 45

3.7: Average Concentrations of Conventional Contaminants and Metals in Composite Samples of Effluents During Winter Sampling Program 47

3.8: Concentrations of Trace Organic Compounds Detected in Effluent Samples, Winter Sampling Program 49

4.1: Comparison of Grab vs. Composite Sample Test Results for Estimation of Acute Effluent Lethality 55

4.2: Categorization of STPs by Industrial Contribution 65

4.3: Classification of STPs by Operating Condition 71

4.4: Multiple Regression Analysis of STP Effluent Chemistry versus Acute Toxicity to Rainbow Trout 106

4.5: Comparison of STP Effluent Chemistry to Concentrations Reported as Lethal to Rainbow Trout 108

4.6: Multiple Regression Analysis of STP Effluent Chemistry versus Acute Toxicity to *Daphnia magna* 115

Page

4.7: Comparison of STP Effluent Chemistry to Concentrations Reported as Lethal to Daphnia magna 117

4.8: Multiple Regression Analysis of STP Effluent Chemistry versus Chronic Toxicity to Fathead Minnows - Low TRC Samples Only 120

4.9: Comparison of STP Effluent Chemistry to Concentrations Reported to be Chronically Toxic to Fathead Minnows 123

4.10: Multiple Regression Analysis of STP Effluent Chemistry versus Chronic Toxicity to Ceriodaphnia dubia - Low TRC Samples Only 126

4.11: Comparison of Effluent Chemistry to Concentrations Reported to be Chronically Toxic to Ceriodaphnia dubia 127

4.12: Toxicity of Organic Chemicals Found in Ontario STP Effluents 132

## LIST OF FIGURES

Figure No.

2.1: Geographic Location of Plants Included in STP Toxicity Study 9

2.2: Overview of Sampling and Testing Procedures for Grab Samples 14

2.3: Overview of Sampling and Testing Procedures for Composite Samples 15

3.1: Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Summer vs. Winter 30

3.2: Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Before and After Dechlorination 31

3.3: Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Composite vs. Grab 32

3.4: Relative Distribution of Daphnia magna LC50's for Effluent Samples - Summer vs. Winter 34

3.5: Relative Distribution of Daphnia magna LC50's for Effluent Samples - Before and After Dechlorination 35

3.6: Relative Distribution of Daphnia magna LC50's for Effluent Samples - Composite vs. Grab 36

3.7: Relative Distribution of Fathead Minnow Chronic LC50's for Composite Effluent Samples - Summer vs. Winter 37

3.8: Relative Distribution of Fathead Minnow Chronic Values for Composite Effluent Samples - Summer vs. Winter 40

3.9: Relative Distribution of C. dubia Chronic LC50's for Composite Effluent Samples - Summer vs. Winter 41

3.10: Relative Distribution of C. dubia Chronic Values for Composite Effluent Samples - Summer vs. Winter 42

4.1: Effect of Sample Type on Rainbow Trout Lethality 52

4.2: Effect of Sample Type on Daphnia magna Lethality 53

4.3: Effect of Seasonal Conditions on Rainbow Trout Lethality 57

4.4: Effect of Seasonal Conditions on Ceriodaphnia Toxicity 59

4.5: Effect of Seasonal Conditions on Fathead Minnow Toxicity 60

4.6: Effect of Plant Type on Rainbow Trout Toxicity 61

Page

4.7: Effect of Plant Type on Ceriodaphnia Toxicity 63

4.8: Effect of Plant Type on Fathead Minnow Toxicity 64

4.9: Effect of Industrial Load on Rainbow Trout Toxicity 67

4.10: Effect of Industrial Load on Ceriodaphnia Toxicity 68

4.11: Effect of Industrial Load on Fathead Minnow Toxicity 69

4.12: Effect of Hydraulic Loading on Rainbow Trout Toxicity 73

4.13: Effect of F/M Loading on Rainbow Trout Toxicity 74

4.14: Effect of SRT on Rainbow Trout Toxicity 75

4.15: Effect of Aeration Tank HRT on Rainbow Trout Toxicity 76

4.16: Effect of Hydraulic Loading on Ceriodaphnia Toxicity 77

4.17: Effect of Hydraulic Loading on Fathead Minnow Toxicity 78

4.18: Effect of F/M Loading on Ceriodaphnia Toxicity 79

4.19: Effect of SRT on Ceriodaphnia Toxicity 80

4.20: Effect of Aeration Tank HRT on Ceriodaphnia Toxicity 82

4.21: Effect of F/M Loading on Fathead Minnow Toxicity 83

4.22: Effect of SRT on Fathead Minnow Toxicity 84

4.23: Effect of Aeration Tank HRT on Fathead Minnow Toxicity 85

4.24: Change in Effluent Total Ammonia During Sample Transport from STP to Toxicity Laboratory 86

4.25: Change in Effluent Total Residual Chlorine During Sample Transport from STP to Toxicity Laboratory 88

4.26: Change in Sample pH Between Beginning and End of Acute Rainbow Trout Tests 90

4.27: Change in Sample pH Between Beginning and End of Acute Daphnia magna Tests 91

4.28: Change in Sample pH Between Beginning and End of Chronic Fathead Minnow Tests 92

Page

4.29: Change in Sample pH Between Beginning and End of Chronic C. dubia Tests 93

4.30: Changes in Effluent Sample Nitrogen During Rainbow Trout Tests 94

4.31: Changes in Effluent Sample Nitrogen During Fathead Minnow Tests 95

4.32: Change in Un-ionized Ammonia Concentrations Between Beginning and End of Acute Rainbow Trout Tests 97

4.33: Change in Un-ionized Ammonia Concentrations Between Beginning and End of Chronic Fathead Minnow Tests 98

4.34: Comparison Between STP Effluent Toxicity to Rainbow Trout and Daphnia magna for Each Sample 100

4.35: Comparison Between Chronic LC50 Results Generated for Each STP Sample Using Fathead Minnow and C. dubia 101

4.36: Comparison Between Chronic Values Generated for Each STP Sample Using Fathead Minnow and C. dubia Tests 102

4.37: Toxicity of STP Effluents to Rainbow Trout as a Function of Initial TRC Concentrations 110

4.38: Toxicity of STP Effluents to Rainbow Trout as a Function of Initial Un-ionized Ammonia Concentrations 112

4.39: Toxicity of STP Effluents to Daphnia magna as a Function of Initial TRC Concentrations 116

4.40: Toxicity of STP Effluents to Daphnia magna as a Function of Initial Un-ionized Ammonia Concentrations 118

4.41: Toxicity of STP Effluents to Fathead Minnow as a Function of Un-ionized Ammonia Concentrations 122

4.42: Toxicity of STP Effluents to C. dubia as a Function of Un-ionized Ammonia Concentrations 128

## GLOSSARY OF TERMS AND ABBREVIATIONS

| | |
|---|---|
| Acute Toxicity: | A discernible adverse effect (lethal or sublethal) induced in the test organisms within a short period of exposure to a test material, usually representing a small portion of the life span of the test species. |
| $BOD_5$: | Biochemical Oxygen Demand exerted in five days under controlled conditions. |
| Chronic Toxicity: | A discernible adverse effect (lethal or sublethal) induced in test organisms over a long portion of the life span of a test species (note: the seven-day fathead minnow test does not precisely fit this definition, but is also not an acute test; in order to simplify discussion of toxicity test results throughout the report, however, it was considered to be a chronic test). |
| Culture: | As a noun, it means the stock of animals or plants that is raised under defined and controlled conditions in order to produce test organisms. As a verb, it means to carry out this procedure of raising organisms. |
| DAF: | Dissolved Air Flotation |
| DOC: | Dissolved Organic Carbon. |
| Endpoint: | The variables (i.e., time, reaction of the organisms, etc.) that indicate the termination of a test, and also means the measurement(s) or value(s) derived, that characterize the results of the test (NOEC, LC50, etc.). |
| FRC: | Free Residual Chlorine |
| F/M: | Food to Microorganism Ratio. The organic loading on the biological reactor of a wastewater treatment plant measured as kg $BOD_5$ applied to the reactor per kg of biological matter in the reactor (measured as volatile suspended solids) per day. |
| HRT: | Hydraulic Retention Time. The nominal liquid residence time in a tank calculated by dividing the tank volume by the liquid flow. |
| HAZPRED: | A predictive model developed by Canviro Consultants Limited (Canviro, 1984) to predict the concentration of hazardous contaminants in a sewage collection system based on the inputs from residential, commercial and industrial sources. |
| ICp: | Inhibition Concentration percentage. It represents a point estimate of the concentration of test material that causes a specified percentage reduction in a qualitative biological measurement such as growth of fish. For example, an IC25 would be the concentration estimated to cause a 25% reduction in growth of larval fish, relative to the control. |
| I/I: | Infiltration and Inflow |

| | |
|---|---|
| Larva: | A recently hatched fish which as physical characteristics other than those seen in the adult fish. The larval period begins with hatching of the embryo and lasts until the disappearance of the last vestige of the median fin fold and the appearance of a full complement of fin rays and spines. Fathead minnows are considered larvae for the first few days after hatching. |
| LC50: | Median lethal concentration, i.e., the concentration of material in water that is estimated to be lethal to 50% of the test organisms. The LC50 and its 95% confidence limits are usually derived by statistical analysis of mortalities in several test concentrations, after a fixed period of exposure. The duration of exposure must be specified (e.g., 96-h LC50). |
| Lethal: | Causing death by direct action. Data tables distinguish between samples which caused no lethality (NL) and those which resulted in lethality of more than 0% but less than 50% of exposed organisms (LC50 greater than 100%). To simplify discussion, the two cases were not distinguished from each other in the text, and all such samples were referred to as non-lethal. |
| LOEC: | Lowest-Observed-Effect Concentration. This is the lowest concentration of test material to which organisms are exposed, which causes adverse effects on the organism, effects which are detected by the observer. (For example, LOEC might be the lowest concentration at which growth of fish differed significantly from that in the control.) LOEC is generally reserved for sublethal effects, but can also be used for mortality, which may sometimes be the most sensitive effect observed. |
| MIGD: | Million Imperial Gallons per Day |
| MLVSS: | Mixed Liquor Volatile Suspended Solids. A measure of biological matter in an STP aeration tank. |
| $NH_3$-N: | Total ammonia concentration reported as mg/L nitrogen. |
| $NO_2$-N: | Nitrite concentration reported as mg/L nitrogen. |
| $NO_3$-N: | Nitrate concentration reported as mg/L nitrogen. |
| NOEC: | No-Observed-Effect Concentration. This is the highest concentation of a test material to which organisms are exposed, which does not cause any observed adverse effects on the organism (e.g., value of an observed variable such as growth does not differ significantly from that in the control). NOEC customarily refers to sublethal effects, and to the most sensitive effect unless otherwise specified. |
| P: | Phosphorus |
| SIC: | Standard Industrial Classification |

| | |
|---|---|
| SRT: | Solids Retention Time. The length of time that the biological solids are retained in the treatment system, calculated by dividing the mass of solids present in the system by the amount of solids intentionally and unintentionally removed from the system daily. |
| STP: | Sewage Treatment Plant |
| Secondary Treatment: | An STP which incorporates a biological treatment process such as activated sludge for removal of dissolved organic contaminants. The STP may also incorporate phosphorus removal within the biological reactor, either by chemical or biological processes. |
| Static: | Toxicity tests in which test solutions are not renewed during the test. |
| Static Replacement: | Toxicity tests in which test solutions are renewed (replaced) periodically during the test, usually every 24 h. Synonymous terms are "batch replacement", "renewed static", "renewal", "static renewal" and "semi-static". |
| Sublethal: | Detrimental to the fish, but below the level which directly causes death within the test period. |
| Tertiary Treatment: | An STP which incorporates a polishing step such as filtration after the biological treatment process to improve removal of suspended solids from the effluent. |
| TOC: | Total Organic Carbon |
| Toxicity Identifcation Evaluation: | A systematic sample pre-treatment (e.g., pH adjustment, filtration, aeration, etc.) followed by tests for acute toxicity. This evaluation is used to identify the causative agent(s) which are primarily responsible for acute lethality in a complex mixture. |
| Toxicity Test: | A determination of the effect of a material on a group of selected organisms, under defined conditions. An aquatic toxicity test usually measures the proportions of organisms affected by their exposure to specific concentrations of chemical, effluent, elutriate, leachate or receiving water. |
| TRC: | Total Residual Chlorine. |
| TSS: | Total Suspended Solids. |
| UMIS: | Utility Monitoring Information System. An MOE database of STP performance and operational data for Ontario. |
| VSS: | Volatile Suspended Solids. |

# 1.0 INTRODUCTION

## 1.1 Background - Phase I

Environment Canada and the Ontario Ministry of the Environment (MOE) recognize the need for development of effluent discharge limits for sewage treatment plants (STPs) in support of the goals of MOE's Municipal and Industrial Strategy for Abatement Program (MISA). While provincial water quality objectives can provide the basis of chemical limits, acute lethality tests using rainbow trout and Daphnia magna are the only formal measures of effluent toxicity in the province.

In February 1988, BEAK completed a study (Phase I) which reviewed the available toxicity data of municipal sewage treatment plants in Ontario and other provinces (BEAK, 1988). The objectives of that report were to determine:

- whether STPs could be categorized with respect to effluent toxicity according to plant type (i.e., primary, secondary and lagoon) and process performance measured in terms of $BOD_5$ and ammonia removal; and
- which plants should be evaluated through field sampling and testing to provide a toxicity database that would assist development of achievable toxicity limits for each plant category.

Review of toxicity and process data for plants indicated that effluent lethality is not related simply to the type of treatment process involved (i.e., primary, secondary or lagoon), but to conditions specific to each plant as well. Toxicity due to ammonia was demonstrated by laboratory test results of STP effluents in Ontario. Both high total ammonia-N concentrations and poor $BOD_5$ removal efficiency may be responsible for the toxic effluents from primary plants. In secondary plants, in spite of high $BOD_5$ removal efficiencies (e.g., greater than 80%), effluents were frequently toxic if the total ammonia-N concentration exceeded 10 mg/L. This was very often the case during winter operation, with high total ammonia-N levels apparently resulting from reduced nitrification at lower wastewater temperatures. Effluent toxicity associated with lagoon operation was most frequently associated with both high total ammonia-N concentrations and poor $BOD_5$ removal efficiency, rather than with high total ammonia-N concentrations alone. As with the primary effluents, the toxicity may be due to ammonia or other toxicants such as hydrogen sulphide. Process operating efficiency, as measured in terms of total $NH_3$-N seems to be a more reliable determinant of effluent lethality than the type or amount of industrial input. However, the data available related to industrial inputs were limited. Chlorine toxicity in effluents was shown in continuous-flow tests in the laboratory, as well as in in situ field studies. It was noted that conventional static bioassays allow dissipation of total residual chlorine and, therefore, result in an inaccurate reflection of its toxic potency. Furthermore, it was concluded that, at some STPs, other toxic components may be involved, such as metals, surfactants and organics. Lastly, the report stated that the literature on sublethal or chronic toxicity of treated STPs' effluents was limited. It was recommended that an intensive evaluation of STP effluent toxicity be completed on selected plants from each identified category that are representative of good operational performance. Ultimately, the data accumulated from effluent toxicity tests and chemical analyses will be used by the MOE to establish toxicity limits for STP discharges.

## 1.2 Objectives - Phase II

Primary treatment STPs were not included in the Phase II study, since the Phase I evaluation (BEAK, 1988) indicated that primary plant effluents are likely to be acutely lethal. The Phase II study focused on secondary and tertiary STPs, as well as lagoons, in order to:

- compare the frequency of lethal vs. non-lethal effluent samples collected from Ontario STPs;
- quantify the proportion of STP effluent acute lethality resulting from free and total chlorine, un-ionized ammonia and other effluent constituents;
- quantify and relate the sublethal toxicity of Ontario STP effluents to contaminant concentrations;
- identify whether contaminants from industrial discharges contribute to effluent toxicity;
- determine the acute and chronic toxicity removal efficiency of STPs under summer compared to winter conditions;
- compare the acute toxicity of grab samples and 24-hour composite samples of Ontario STP effluents.

## 1.3 Overview of Project Scope

Composite and grab samples of final treated effluent from six secondary, two tertiary and two lagoon sewage treatment plants in Ontario were collected by CH2M HILL Engineering Limited and delivered to the laboratories of Beak Consultants Limited (BEAK) for evaluation of acute (rainbow trout and *Daphnia magna*) lethality and chronic (fathead minnow survival and growth test and *Ceriodaphnia dubia* survival and reproduction) toxicity. Measurement of total residual chlorine (TRC), free chlorine, ammonia and pH were completed on-site upon sample collection and upon arrival at the BEAK laboratory. Analyses of conventional pollutants and metals on each of the effluent samples were completed by the Ontario Ministry of the Environment (MOE). Analysis of organics were performed on selected samples by the MOE.

All plants were visited during both summer and winter to reflect potential seasonal differences in operation. Four composite samples were collected from each STP during each seasonal sample collection exercise. A limited number of grab samples (44 in total) were collected from five of the sewage treatment plants.

## 2.0 STUDY DESIGN AND METHODOLOGY

### 2.1 Site Selection

In the literature review of municipal sewage treatment plant (STP) effluent toxicity in Ontario that preceded this full-scale survey (BEAK, 1988), a rationale for selection of STPs for testing was proposed. General criteria for including plants in the survey were:

- efficient plant operation;
- varying industrial input; and
- seasonal ammonia variability to assess the impact of this compound at high and low levels.

Data from the MOE's "Report on the 1985 Discharges from Municipal Wastewater Treatment Facilities in Ontario" (MOE, 1987a) were used to assess the performance of STPs in the province. Efficient plant operating criteria were defined as:

- relative hydraulic loading (annual mean daily flow divided by design mean daily flow) between 75% and 110%; and
- $BOD_5$ removal efficiency of 80% for lagoons and secondary mechanical plants, or 50% for primary plants.

Ammonia data from 1986 were also obtained from the Ministry's UMIS database to evaluate seasonal ammonia variability due to partial or complete nitrification. Some facilities reported monthly average ammonia concentrations while other plants reported only an annual average level. The classification criterion applied in this case was that the effluent ammonia concentration was less than 10 mg/L for three to six months of the year (at least 3 to 4 consecutive months) or less than 10 mg/L on an annual basis.

Finally, all STPs in the province were classified by estimated industrial input using the dry weather HAZPRED model developed by CH2M Hill Engineering Limited (then CANVIRO Consultants Ltd.) for the MOE (CANVIRO Consultants Ltd., 1984). This model estimates residential, commercial, and industrial contributions, as well as infiltration and inflow (I/I), to municipal wastewater flows entering a STP. Because of the limited calibration of the model and the highly variable I/I component, professional judgment was applied to finalize industrial flow inputs. Treatment plants were rated as being either domestic (less than 5% industrial flow), minor industrial (5-30% industrial flow) and major industrial (greater than 30% industrial flow).

The list of STPs that met these selection criteria is presented in Table 2.1. A minor variance from the criteria can be found in the lagoons rated as treating domestic wastewater. Because the criteria as stated screened out most lagoons in this category, the hydraulic capacity criterion was relaxed to include 3 lagoons with hydraulic capacity less than 75% of design.

From the list of STPs in Table 2.1, the following plants were selected:

Perth
Lindsay
Bracebridge
Huntsville

Sudbury
Stratford
Walkerton
Metro Toronto North

A major objective of the study was to assess the impact of non-conventional hazardous contaminants, discharged by industry to municipal sewers, on STP effluent toxicity. Therefore, two additional plants (Metro Toronto Highland Creek and Midland) were added to increase the assessment of plants with a large industrial contribution. As noted in Appendix D of the Phase I report (BEAK, 1988), the former plant is rated as having ammonia levels greater than 10 mg/L for 10 or more months of the year, while at Midland, the ammonia levels exceed 10 mg/L for 4 to 6 months per year. There is no apparent seasonal pattern for ammonia at Midland.

In the course of the study, a labour strike by municipal workers at the Sudbury plant prevented access to the site for sampling. As a result, Sudbury was dropped from the study and the Wallaceburg plant was substituted. Data from the Ministry's "Report on the 1987 Discharges from Sewage Treatment Plants in Ontario" (MOE, 1988b) indicated that Wallaceburg's mean daily flow was about 90% of design and had a $BOD_5$ removal efficiency of 90%. Monthly mean effluent ammonia levels exceeded 10 mg/L 8 months of the year, based on UMIS data for 1988 obtained from the Ministry. The plant was rated as receiving minor industrial flow (5 to 30%) in the Phase I study (BEAK, 1988).

## TABLE 2.1: LIST OF CANDIDATE STPs FOR FULL-SCALE EFFLUENT TOXICITY MONITORING PROGRAM

| Industrial Component | Primary | Secondary | | Lagoons |
|---|---|---|---|---|
| Domestic | Kingston<br>Fort Eric<br>(Anger Avenue) | Vaughan<br>Halton Hills (Acton)<br>Onaping Falls (Onaping)<br>Onaping Falls (Levack)<br>Onaping Falls (Dowling)<br>Bracebridge | London (Oxford)<br>Penetanguishene<br>Gravenhurst<br>Haldimand (Caledonia)<br>Timmins (Whitney) | Lakefield<br>Brighton*<br>Nanticoke (Waterford)<br>Kincardine* |
| Minor | Owen Sound<br>Prescott<br>Thunder Bay | Guelph<br>Flamborough<br>Walkerton<br>Welland<br>Peterborough<br>Sudbury<br>Orillia | London (Adelaide)<br>London (Greenway)<br>London (Pottersburg)<br>Whitby (Pringle Cr. No. 1)<br>Huntsville<br>Milton<br>Waterloo | Alexandria<br>Lindsay<br>Perth<br>Niagara-on-the-Lake<br>Strathroy |
| Major | Windsor (Westerly)<br>Gloucester<br>(Greens Crescent) | Chatham<br>Mississauga (Lakeview)<br>Midland<br>Halton Hills (Georgetown)<br>Port Colborne (Seaway)<br>Pickering (Duffins Cr.) | Metro Toronto (North)<br>London (Vauxhall)<br>Stratford<br>Port Hope<br>Oshawa (Harmony Cr.No.1)<br>Whitchurch-Stouffville | |

**Selection Criteria:**

1. **Hydraulic loading 75 to 110% of design flow.**
2. **BOD removal efficiency:** 80% for lagoons and secondary
   50% for primary plants
3. **Effluent ammonia concentration:** Less than 10 mg/L for 0 to 6 months, or
   Less than 10 mg/L on an annual basis

* **Less than 75% of design flow.**

The finalized list of plants and data describing these STPs is presented in Table 2.2. The geographic location of each of the plants is presented in Figure 2.1.

## 2.2 Sampling Schedule

Each of the ten STPs included in the effluent toxicity sampling program was sampled on two separate occasions, once during warm weather conditions and once during cold weather conditions. On each occasion, four 24-hour composite samples of the final effluent from the STP were collected on Wednesday, Thursday, Friday and Saturday morning with the single exception of the cold weather sampling at the Bracebridge STP which commenced on Tuesday morning and was completed on Friday morning due to schedule constraints. The sampling schedules for the cold weather and warm weather programs are presented in Table 2.3. All warm weather sampling was done during the months of June, July, August and September when ambient and wastewater temperatures were considered to be at or near their highest summer levels. Cold weather sampling was conducted in December, January, February and March to be reflective of lower, winter ambient and wastewater temperatures.

At selected STPs, grab samples of final effluent were also collected. The schedule of grab sampling events is presented in Table 2.4. A total of 22 grab samples were collected during each part of the sampling program, for an overall total of 44 grab samples. Grab sampling at the Wallaceburg and Midland plants included late Friday evening and early Saturday morning when it was felt that weekly industrial cleanup operations might occur.

## 2.3 Pre-Sampling Monitoring

In order to ensure that the toxicity data collected at the selected STPs were representative of "typical" plant operation, operational and performance data for the weeks prior to the sampling as well as the week of toxicity sampling were collected for review. At plants which did not have a regular raw sewage and final effluent sampling scheduled for the week prior to the toxicity sampling period, arrangements were made to have samples collected and submitted to the MOE Laboratory for analysis of conventional contaminants.

TABLE 2.2: DESCRIPTION OF STPs INCLUDED IN SAMPLING PROGRAM

| STP | Type | Operating Authority | Flow (1,000 $m^3/d$) Design | Flow (1,000 $m^3/d$) Average (1988) |
|---|---|---|---|---|
| 1. Lindsay | Conventional Lagoon<br>P Removal<br>Continuous Discharge<br>No Disinfection | Municipal | 17.18 | 13.55 |
| 2. Perth | Conventional Lagoon<br>P Removal<br>Continuous Discharge<br>No Disinfection | Municipal | 5.91 | 6.11 |
| 3. Bracebridge | Extended Aeration<br>Effluent Polishing<br>P Removal<br>Year-Round Disinfection | Municipal | 3.19 | 2.60 |
| 4. Huntsville | Conventional Activated Sludge<br>P Removal<br>Year-Round Disinfection | Municipal | 4.55 | 3.89 |
| 5. Walkerton | Conventional Activated Sludge<br>P Removal<br>Seasonal Disinfection | Municipal | 7.55 | 4.74 |
| 6. Stratford | Conventional Activated Sludge<br>Effluent Polishing<br>P Removal<br>Seasonal Disinfection | MOE | 27.28 | 22.06 |
| 7. Toronto North | Conventional Activated Sludge<br>P Removal<br>Year-Round Disinfection | Municipal | 45.46 | 34.87 |
| 8. Toronto Highland Creek | Conventional Activated Sludge<br>P Removal<br>Year-Round Disinfection | Municipal | 218.20 | 151.69 |
| 9. Midland | Conventional Activated Sludge<br>P Removal<br>Seasonal Disinfection | Municipal | 13.64 | 11.32 |
| 10. Wallaceburg | Conventional Activated Sludge<br>P Removal<br>Year-Round Disinfection | MOE | 6.82 | 6.12 |

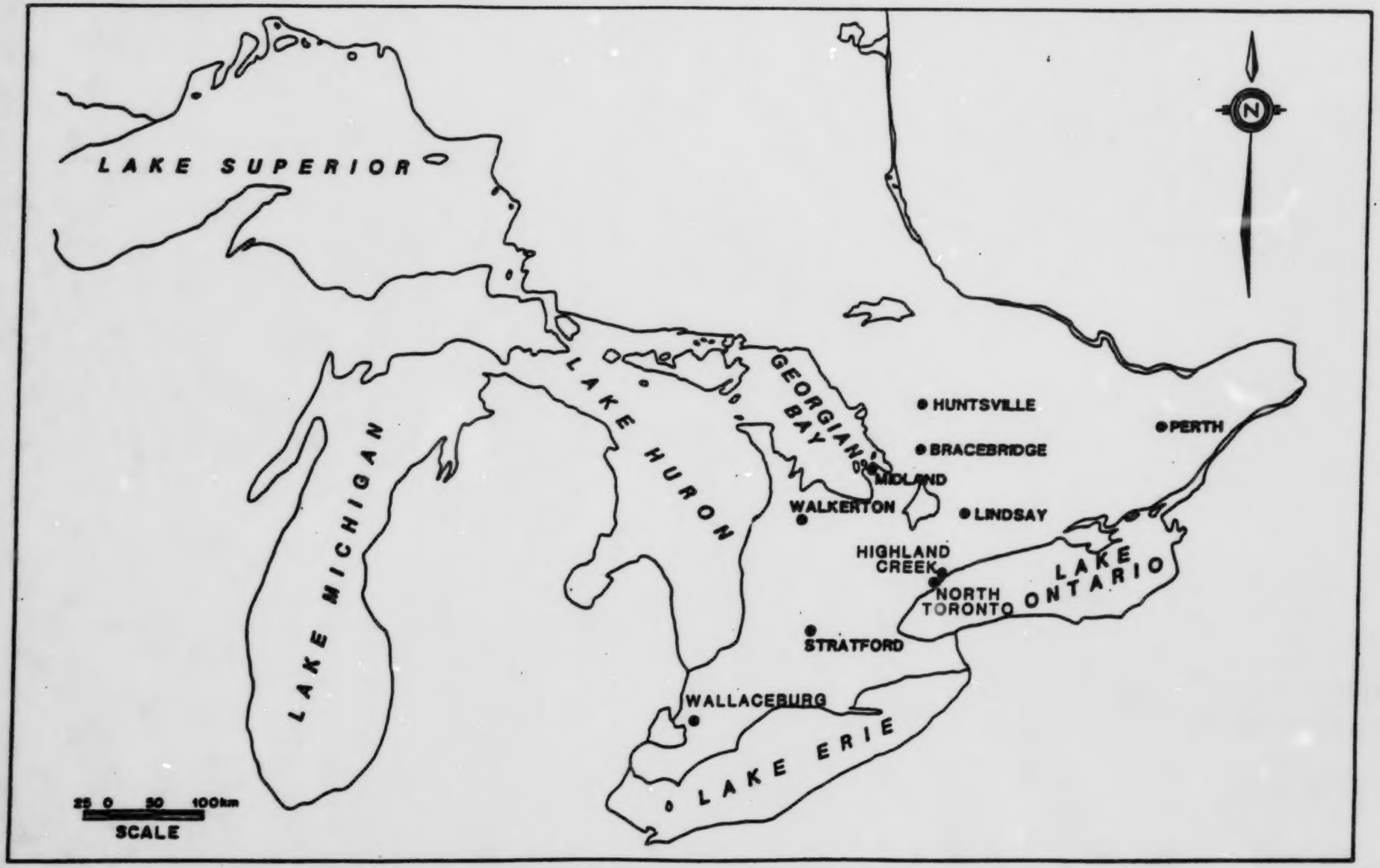

LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
LAKE ERIE
LAKE ONTARIO
N
HUNTSVILLE
BRACEBRIDGE
MIDLAND
WALKERTON
LINDSAY
PERTH
HIGHLAND CREEK
NORTH TORONTO
STRATFORD
WALLACEBURG
25 0 50 100km
SCALE

FIGURE 2.1: GEOGRAPHIC LOCATION OF PLANTS INCLUDED IN STP TOXICITY STUDY

TABLE 2.3: STP SAMPLING SCHEDULE

| Program | STP | Sampling Dates |
|---|---|---|
| Cold Weather | North Toronto | 14-18 March 1989 |
| | Highland Creek | 21-25 March 1989 |
| | Lindsay | 28 March - 01 April 1989 |
| | Huntsville | 05-09 December 1989 |
| | Bracebridge | 11-15 December 1989 |
| | Midland | 09-13 January 1990 |
| | Walkerton | 16-20 January 1990 |
| | Wallaceburg | 23-27 January 1990 |
| | Stratford | 13-17 February 1990 |
| | Perth | 20-24 February 1990 |
| Warm Weather | Highland Creek | 06-10 June 1989 |
| | North Toronto | 13-17 June 1989 |
| | Walkerton | 20-24 June 1989 |
| | Stratford | 11-15 July 1989 |
| | Midland | 18-22 July 1989 |
| | Bracebridge | 25-29 July 1989 |
| | Huntsville | 15-19 August 1989 |
| | Lindsay | 22-26 August 1989 |
| | Wallaceburg | 05-09 September 1989 |
| | Perth | 12-16 September 1989 |

TABLE 2.4: SCHEDULE OF GRAB SAMPLES

| Plant | No. of Grab Samples | | Time of Collection | |
|---|---|---|---|---|
| | Winter | Summer | | |
| Toronto Highland Creek | 4 | 4 | Wednesday | 13:00 hr |
| | | | Thursday | 13:00 hr |
| | | | Friday | 13:00 hr |
| | | | Saturday | 08:00 hr |
| Lindsay | 3 | 3 | Wednesday | 08:00 hr |
| | | | Thursday | 08:00 hr |
| | | | Friday | 08:00 hr |
| Perth | 3 | 3 | Wednesday | 08:00 hr |
| | | | Thursday | 08:00 hr |
| | | | Friday | 08:00 hr |
| Midland | 6 | 6 | Wednesday | 13:00 hr |
| | | | Thursday | 13:00 hr |
| | | | Friday | 13:00 hr, 19:00 hr, 24:00 hr |
| | | | Saturday | 08:00 hr |
| Wallaceburg | 6 | 6 | Wednesday | 13:00 hr |
| | | | Thursday | 13:00 hr |
| | | | Friday | 13:00 hr, 19:00 hr, 24:00 hr |
| | | | Saturday | 08:00 hr |

Arrangements were also made with plant staff to acquire schematic flow sheets of the plants and fundamental plant design data.

Detailed descriptions of each STP facility, historical performance, and operating conditions during the pre-sampling monitoring period are presented in Appendix A.

## 2.4 Sample Collection and Transport

### 2.4.1 Composite Samples

Twenty-four hour composite samples of final effluent were collected for four days at each STP during each sampling period (cold weather and warm weather) as identified in Section 2.2. Peristaltic pumps were used to collect the sample into two 100-L polypropylene tanks. Pumping rates were set to collect a total of approximately 190 litres over a 24-hour period.

The polypropylene tanks were contained in refrigerators. Each tank was equipped with a floating lid so that there was no headspace above the liquid in the sample container. Sample temperatures were maintained between 5°C and 15°C during collection. During the summer sampling period, when STP effluent temperatures exceeded 20°C, the final effluent sample was precooled by pumping through the freezer compartment of the sample refrigerator prior to storage in the polypropylene tank.

At the completion of the twenty-four hour sampling period, the sample containers were mixed using a submersible pump immersed in each sample tank. Equal volumes from each tank were then transferred to 22-litre polyethylene pails equipped with food-grade polyethylene liners. When full, these liners were secured with elastic bands excluding air from the sealed bags. At STPs which were practicing effluent chlorination, approximately 170 litres were transferred to ensure that adequate sample was available for testing of dechlorinated effluent if required (refer to Section 2.5.3.1). At STPs which were not chlorinating, approximately 125 litres were transferred.

In addition to the 22-L pails transferred for toxicity testing, a 4-L aliquot of the composite sample was transferred to a glass bottle for on-site chemical testing (refer to Section 2.5.1).

### 2.4.2 Grab Samples

At STPs where grab samples were collected, a submersible pump was immersed in the final effluent stream as near as possible to the location of the composite sample pump suction tubing. The grab samples were pumped directly from the sample location into food-grade polyethylene-lined 22-L sample pails. As each liner was filled, the bag was sealed, with air excluded, using the same procedure as applied to the composite samples. At STPs which were practicing chlorination, five pails (approximately 105 litres) were collected for each grab sample. At STPs which were not chlorinating, three pails (approximately 60 litres) were collected.

At each grab sampling event, a 4 litre aliquot was collected in a glass bottle for onsite chemical testing (refer to Section 2.5.1).

### 2.4.3 Sample Transport

After sample collection and transfer to polyethylene pails, the sample pails were packed in ice-filled boxes in a van. The samples were immediately transported to the BEAK laboratories in Mississauga. These samples arrived at the laboratory less than 8 hours after collection with the exception of the multiple grab samples collected at the Wallaceburg and Midland STPs on Friday evenings (refer to Table 2.4). These samples were delivered with the Saturday morning composite and grab samples, arriving at BEAK within the specified 24-hour time limit. Upon arrival at BEAK, samples were immediately transferred to refrigerated storage (4°C) until testing.

## 2.5 Sample Testing

Overviews of the sampling and testing procedures for grab and composite samples are presented in Figures 2.2 and 2.3, respectively.

### 2.5.1 Analytical Chemistry

All effluent samples were tested for pH, total ammonia, and total and free residual chlorine concentrations immediately after receipt at the toxicity laboratory. Subsamples were collected for submission to the MOE laboratory for analysis of conventional

**FIGURE 2.2**
**Overview of Sampling and Testing Procedures for Grab Samples**

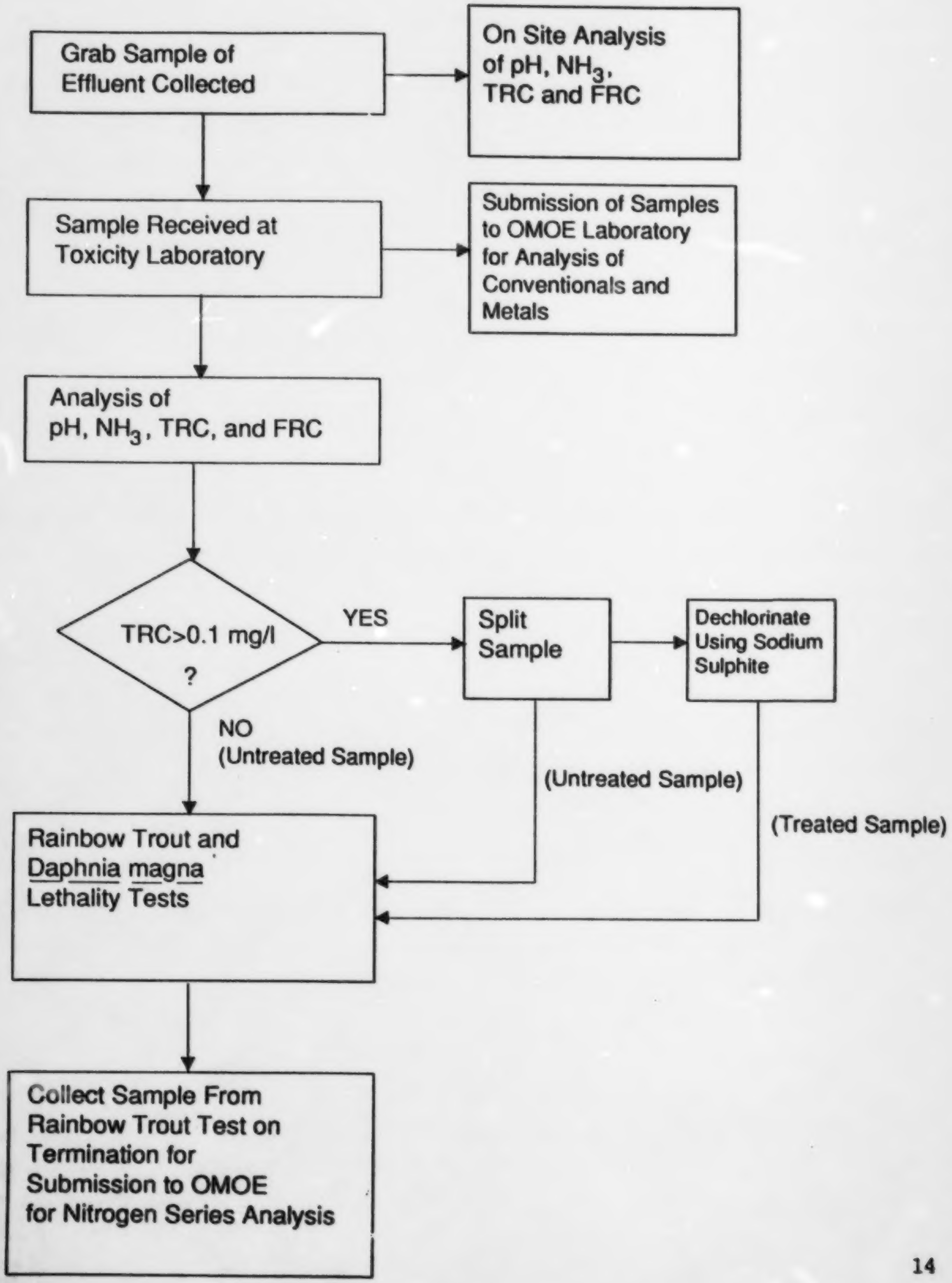
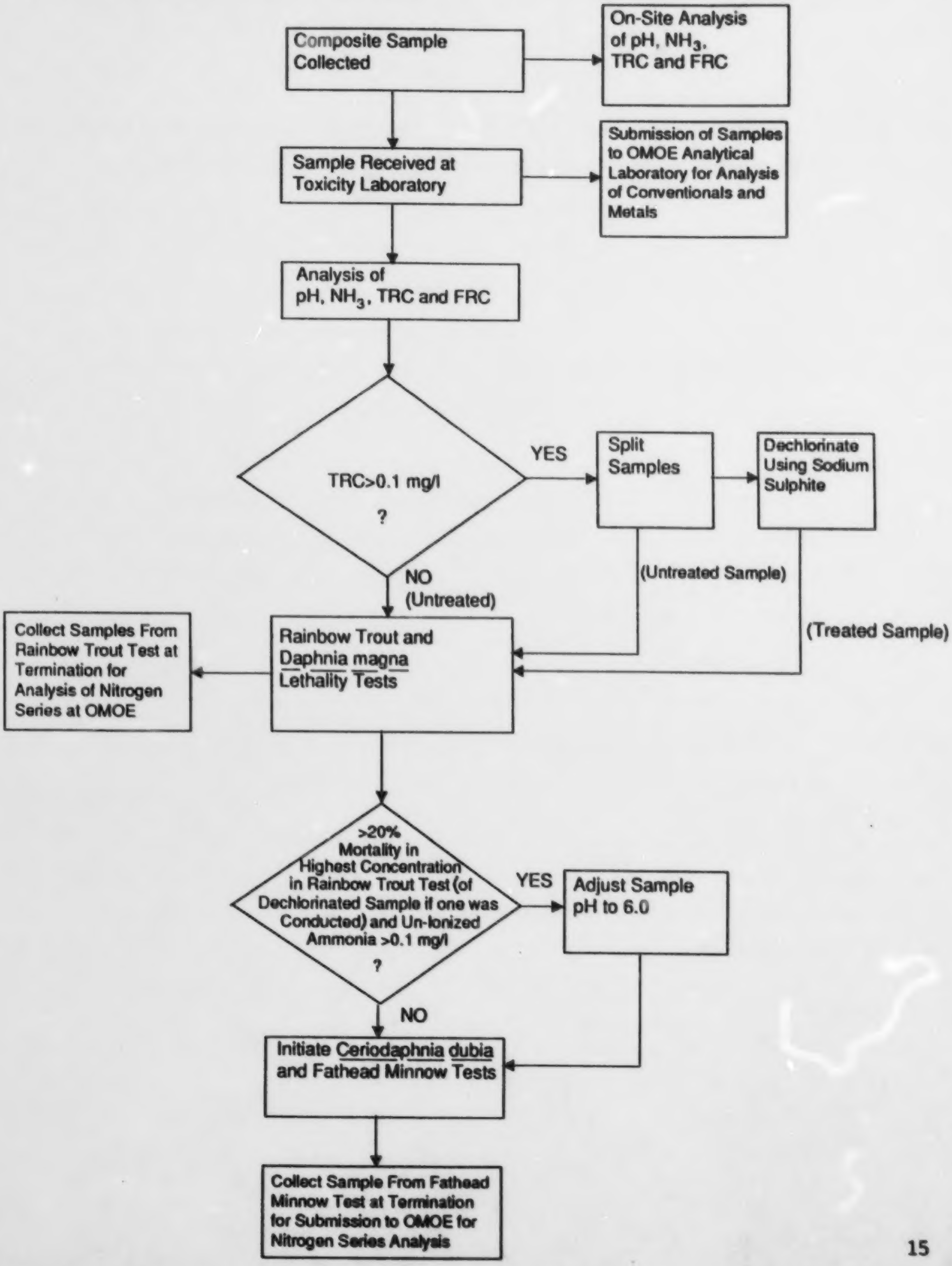

Grab Sample of Effluent Collected
On Site Analysis of pH, $NH_3$, TRC and FRC
Sample Received at Toxicity Laboratory
Submission of Samples to OMOE Laboratory for Analysis of Conventionals and Metals
Analysis of pH, $NH_3$, TRC, and FRC
TRC>0.1 mg/l ?
YES
Split Sample
Dechlorinate Using Sodium Sulphite
NO (Untreated Sample)
(Untreated Sample)
(Treated Sample)
Rainbow Trout and *Daphnia magna* Lethality Tests
Collect Sample From Rainbow Trout Test on Termination for Submission to OMOE for Nitrogen Series Analysis

**FIGURE 2.3**
**Overview of Sampling and Testing Procedures for Composite Samples**


Composite Sample Collected
On-Site Analysis of pH, $NH_3$, TRC and FRC
Sample Received at Toxicity Laboratory
Submission of Samples to OMOE Analytical Laboratory for Analysis of Conventionals and Metals
Analysis of pH, $NH_3$, TRC and FRC
TRC>0.1 mg/l ?
YES
Split Samples
Dechlorinate Using Sodium Sulphite
NO (Untreated)
(Untreated Sample)
(Treated Sample)
Rainbow Trout and Daphnia magna Lethality Tests
Collect Samples From Rainbow Trout Test at Termination for Analysis of Nitrogen Series at OMOE
>20% Mortality in Highest Concentration in Rainbow Trout Test (of Dechlorinated Sample if one was Conducted) and Un-Ionized Ammonia >0.1 mg/l ?
YES
Adjust Sample pH to 6.0
NO
Initiate Ceriodaphnia dubia and Fathead Minnow Tests
Collect Sample From Fathead Minnow Test at Termination for Submission to OMOE for Nitrogen Series Analysis

parameters and metals. The samples were delivered to the MOE via 90-minute courier service, except weekend samples which were held until Monday, then couriered. Samples collected on Saturdays were kept refrigerated until Monday and then delivered by courier.

Subsamples were also collected from composite samples for organics analysis. These were kept refrigerated (4°C) at BEAK pending the results of the chronic toxicity tests (see Section 2.5.3.3 for details).

### 2.5.1.1 On-Site Analytical Testing

At the time of sample collection, all grab and composite samples were analyzed in the field for pH, ammonia-N, total residual chlorine (TRC) and free residual chlorine (FRC). pH measurements were done using the standard electrometric glass electrode method.

Ammonia concentrations were measured by the Nesslerization method using a portable spectrophotometer (HACH Model DR/2) and prepackaged reagents. Standard solutions prepared by CANVIRO Analytical Laboratories Ltd. and HACH were used for method calibration. Matrix spikes were routinely analyzed to verify the procedure (Appendix C).

TRC and FRC analyses were conducted using the amperometric titration (Wallace & Tiernan or Fischer & Porter Co. Ltd. method according to Standard Methods, Method 408B (APHA, 1985).

### 2.5.1.2 Analytical Testing at the Toxicity Laboratory

At the time of sample receipt, all grab and composite samples were analyzed for TRC/FRC and total ammonia. Ammonia concentrations were measured by the Nesslerization method using a portable spectrophotometer (HACH Model DR/1A) and HACH reagents. Standard solutions prepared by CANVIRO Analytical Laboratories Ltd. and HACH were routinely analyzed to verify the procedure.

TRC and FRC analyses were conducted using the amperometric titration (Fischer and Porter Co. Ltd.) method according to Standard Methods, Method 408B.

### 2.5.1.3 Analysis of Conventionals, Metals and Organics (MOE)

All samples were analyzed for conventional parameters and both total and filtered metals (Table 2.5) at the MOE laboratory. Samples of undiluted effluent were collected at the end of rainbow trout and fathead minnow tests for analysis of nitrogen speciation. Selected samples (Section 2.5.3.3) were also submitted to the MOE for organics analyses.

Performance reports are published annually by the MOE (e.g., MOE, 1988c) including quality control charts, duplicate analysis performance, methodology and instrumentation. Data for the period of this study were not available when this report was prepared but, as per routine practice, all analyses were conducted according to established techniques and quality control was closely monitored.

In addition to routine analysis of duplicates by the chemistry laboratory, one set of duplicate samples (blind duplicates) were submitted to the MOE laboratory during each sampling session at each STP. In addition, a number of the duplicate samples were spiked with a known quantity of ammonia to determine whether ammonia levels changed during storage prior to analysis. Performance on blind duplicates, laboratory (routine) duplicates and spiked samples is discussed in Appendix C.

### 2.5.1.4 Sulphide Analysis

In addition to all those parameters identified in Section 2.5.1.3, lagoon STP (Lindsay, Perth) samples were also analyzed for sulphide levels. Sulphide samples were collected immediately after arrival of the sample at the toxicity laboratory and submitted to Beak Analytical Services. The samples were analyzed within the maximum allowable storage time of seven days. The analytical method was based on those of the MOE (1983a) and APHA (1985).

### 2.5.2 Toxicity Tests

Ninety-six-hour lethality tests using rainbow trout (Oncorhynchus mykiss) were performed according to MOE (1983b). Forty-eight-hour lethality tests using waterfleas (Daphnia magna) were performed according to MOE (1988a).

TABLE 2.5: ANALYTICAL PARAMETERS MEASURED IN STP EFFLUENT SAMPLES

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**Conventional Parameters**

BOD, DOC, nitrate-nitrogen, nitrite-nitrogen, total ammonia-nitrogen, total suspended solids (SS), volatile suspended solids (VSS)

**Metals (Total and Filtered)**

Cu, Ni, Pb, Zn, Fe, Mn, Ag, Al, As, Be, Ca, Cd, Co, Cr, Hg, Mg, Mo, Se, Sr, V

**Organics**

| | |
|---|---|
| Phenolics: | phenol, 2,4-dimethylphenol, p-chloro-m-cresol, 2,4-dichlorophenol, 4-nitrophenol, 2,3,4,6-tetrachlorophenol, 2,4-dinitrophenol, 4,6-dinitro-o-cresol, 2-chlorophenol, 2,4,6-, 2,4,5-, 3,4,5- and 2,3,4-trichlorophenol, 2,3,5,6- and 2,3,4,5-tetrachlorophenol, pentachlorophenol, 2,6-dichlorophenol, m-cresol, o-cresol and p-cresol |
| Polycyclic Aromatic Hydrocarbons (PAHs): | dibenzo(a,h)anthracene, benzo(g,h,i)perylene, naphthalene, acenaphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, 1-chloronaphthalene, 1- and 2-methylnaphthalene, 2-chloronaphthalene, 5-nitroacenaphthene, benzo(b,k)fluoranthene, perylene and benzo(a)anthracene |
| Pesticides: | dicamba, 2,4-D propionic acid, 2,4-D, silvex, 2,4,5-T, 2,4-DB, picloram, hexachlorobenzene, heptachlor, aldrin, p,p-DDE, mirex, a-BHC, b-BHC, g-BHC, a-chlordane, g-chlordane, oxychlordane, o,p-DDT, p,p'-DDD, p,p'-DDT, methoxychlor, heptachloroepoxide, endosulfan I, dieldrin, endrin, endosulfan II, endosulfan sulphate) |
| Other: | octachlorostyrene, indole bis-(2-chloroisopropyl)ether, bis(2-chloroethoxy)methane, 2,6-dinitrotoluene, 4-chlorophenylphenylether, 2,4-dinitrotoluene, N-nitrosodiphenylamine, 4-bromophenylphenylether, di-N-butylphthalate, butylbenzylphthalate, bis-2-ethylhexylphthalate, di-N-octylphthalate, PCB, diphenylamine, bis(2-chloroethyl)ether, camphene, diphenyl ether, N-nitrosodi-N-propylamine |

In both test types, ten organisms were exposed to effluent diluted (with dechlorinated tap water) in an approximately logarithmic scale of concentrations (e.g., 10, 20, 30, 50, 70, 100%). Lethality of organisms was monitored every 24 hours. At the end of the test, the total number of mortalities in each effluent concentration was used to statistically estimate the concentration which would kill 50% of exposed organisms (LC50). Alternatively, the effluent LC50 may be considered as the concentration which would kill an "average" individual of that species.

Fathead minnow (Pimephales promelas) larval survival and growth tests were performed according to the U.S. EPA (1989). Ten newly-hatched fathead minnows (larvae) were exposed to each of a logarithmic dilution series of effluent. Test solutions were renewed daily with the same sample and mortality was recorded at that time. After seven days of exposure, surviving organisms were sacrificed, dried, and weighed. Survival and growth of organisms exposed to each concentration were statistically compared (using hypothesis testing) to control organisms (exposed only to clean water) to measure the lowest concentration at which a significant difference was observed (LOEC). The highest concentration at which no significant difference was observed is termed the highest no-observed-effect concentration (NOEC). The geometric mean of the two concentrations is called the chronic value (Ch.V.), which represents the effluent concentration above which chronic effects on fish survival and/or growth may be expected. This test is generally not considered a true "chronic" test since it does not represent a large portion of the life span of the species (see Glossary), but it also does not fit the traditional concept of an "acute" test (typically less than a few days). Since the introduction of an alternative term (e.g, sub-chronic) would likely hamper rather than enhance the flow and clarity of the report, it was referred to as a chronic test throughout.

Chronic tests were also performed using Ceriodaphnia dubia. C. dubia are waterfleas similar to D. magna, but are smaller in size. The test was performed by exposing ten newly-hatched (neonate), female organisms to each of a logarithmic series of effluent dilutions. Within about three days, each organism matured and asexually reproduced (ie., released more neonates). Each day, test solutions were renewed, and the number of adult mortalities and neonates produced per adult were recorded. The test was terminated after the majority of organisms had produced three broods (usually seven days). Using procedures similar to those described above for the fathead minnow test, the NOEC, LOEC, and Ch.V. were determined for each effluent sample.

Chronic (usually 7-day) LC50s were also estimated for fathead minnow and C. dubia tests.

Details of organism holding/culturing conditions, and test methodology and conditions are presented in Appendix B. Toxicity laboratory QA/QC is discussed in Appendix C.

### 2.5.3 Decision Points in Study Design

It was anticipated that ammonia and TRC would be identified as major toxicants in acute toxicity tests. Another study objective was to identify whether other contaminants were common to Ontario STPs that would cause toxicity to aquatic organisms, particularly in chronic tests. For this reason, it was desirable to minimize the toxic effects of TRC in some acute tests and both TRC and ammonia in chronic tests.

### 2.5.3.1 Residual Chlorine

Chlorine levels above about 0.1 mg/L are known to cause lethality among test organisms (U.S. EPA, 1985b). In order to ascertain the amount of toxicity attributable to other components of the effluent, it was necessary to remove the influence of chlorine. Free (FRC) and total (TRC) residual chlorine were measured by amperometric titration in each effluent sample upon receipt at the toxicity laboratory. Samples containing TRC levels above 0.1 mg/L were dechlorinated using sodium sulphite. TRC was re-analyzed in dechlorinated samples to ensure that the TRC concentration was reduced to less than the MDL (0.01 mg/L). Amperometric titrations were repeated on samples of dechlorinated effluent to ensure that measureable residuals were removed. Parallel acute toxicity tests were conducted on untreated and treated (dechlorinated) samples using rainbow trout and Daphnia magna. Ceriodaphnia dubia and fathead minnow tests were then initiated on the following day using only the dechlorinated effluent sample.

### 2.5.3.2 Un-Ionized Ammonia

Total ammonia levels were measured in each sample immediately after receipt at the toxicity laboratory using HACH equipment and reagents. Un-ionized ammonia levels were calculated based on the total ammonia concentration, sample pH and temperature, according to the relationship developed by Emerson et al. (1975). Acute toxicity tests were then initiated according to methods described previously (Section 2.5.2). The rainbow trout tests conducted on composite effluent samples were checked after 24 hours of exposure to determine the percentage of mortality. In cases where both untreated and dechlorinated samples were run, the dechlorinated sample was checked. If greater than 20% mortality occurred, and the un-ionized ammonia level was greater than 0.1 mg/L, the samples were chemically adjusted to pH 6.0 with reagent-grade sulphuric acid prior to initiation of the chronic tests. This action was based on the assumption that approximately 0.1 mg/L un-ionized ammonia represents the threshold lethal concentration for trout. Adjustment of the effluent pH to 6.0 with reagent-grade sulphuric acid reduced the toxic un-ionized form of ammonia to a very low proportion of the total ammonia nitrogen. This reduced the effects attributable to un-ionized ammonia in the chronic tests in order to also evaluate the effects of other effluent constituents. Deficiencies of this procedure are discussed in Section 4.2.

#### 2.5.3.3 Organics

Subsamples were collected from every composite sample for trace organics analysis and temporarily stored in a 4°C refrigerator. Since the potential array of organic contaminants in any given STP effluent was vast, and due to the expense of analyzing even a relatively narrow range of chemicals, only a selected number of samples were analyzed for organic contaminants. The decision whether or not to submit a sample to the MOE was typically based on the results of the chronic tests. Samples that resulted in particularly low chronic values (high toxicity) for one or both test organisms (Ceriodaphnia dubia or fathead minnows) were identified by the toxicity laboratory and the scientific authority was informed of the results. A joint decision was then made regarding submission of the sample(s) for analysis of extractable organics by GC/MS.

## 3.0 TEST RESULTS

### 3.1 Toxicity Tests

Toxicity test data for all samples collected from the ten STPs are presented in Tables 3.1 (winter) and 3.2 (summer). Details are presented in Appendix E.

### 3.1.1 Acute Lethal Toxicity

### 3.1.1.1 Rainbow Trout

Non-lethality to rainbow trout was consistently achieved by only three of the ten STPs during winter months (Bracebridge, North Toronto, and Walkerton), and by four STPs during summer (Highland Creek, Lindsay, Perth, Walkerton) (Tables 3.1, 3.2 and Appendix E). Winter samples tested as received were more frequently lethal to rainbow trout (71% of samples tested) than those collected in the summer (41% of samples tested) (Table 3.3). Figure 3.1 shows that LC50s tended to be lower (higher toxicity) during winter (also see Section 4.1.3).

Of samples which were split for dechlorination (i.e., those which contained TRC concentrations of 0.1 mg/L or more on receipt at the toxicity laboratory), 77% of samples were acutely lethal when tested as received, relative to 42% of dechlorinated samples (Table 3.3). Dechlorination was particularly effective in summer, since the percentage of lethal samples was reduced from 77% to 22% by dechlorination. Figure 3.2 indicates that LC50s for samples tested as received were distributed toward lower effluent concentrations (greater toxicity) than dechlorinated samples (also see Section 4.4.3).

Composite and grab samples generally showed similar toxicity, although a slightly higher proportion of grab samples were lethal (Figure 3.3; also see Section 4.1.2).

### 3.1.1.2 Daphnia magna

Effluents from six STPs (Bracebridge, Lindsay, Midland, Perth, Stratford, Walkerton) were consistently non-lethal to D. magna in winter, relative to four STPs which produced

Table 3.1 Summary of Toxicity Test Results - Cold Weather Conditions

| | | | Rainbow Trout LC50 (%v/v) | | Daphnia magna LC50 (%v/v) | | Fathead Minnow | | Ceriodaphnia | |
|---|---|---|---|---|---|---|---|---|---|---|
| STP | Date Sample Collected (dd.mm.yy) | Sample Type | As Received | Dechlorinated | As Received | Dechlorinated | Chronic Value (%v/v) | LC50 (%v/v) | Chronic Value (%v/v) | LC50 (%v/v) |
| Bracebridge | 12.12.89 | C | NL | | NL | | 39 | NL | 84 | NL |
| | 13.12.89 | C | NL | | NL | | >100 | NL | 59 | 100 |
| | 14.12.89 | C | NL | | NL | | 24 | NL | >100 | NL |
| | 15.12.89 | C | NL | | NL | | >100 | NL | >100 | NL |
| Highland Creek | 22.03.89 | C | 71 | 71 | NL | NL | 39 | 58 | 39 | NL |
| | 23.03.89 | C | 71 | | NL | | 71 | 73 | 71 | NL |
| | 24.03.89 | C | 71 | | NL | | 39 | 81 | 71 | NL |
| | 25.03.89 | C | 67 | | NL | | 39 | 62 | 71 | 81 |
| | 22.03.89 | G | 39 | 71 | 31 | NL | | | | |
| | 23.03.89 | G | 71 | | NL | | | | | |
| | 24.03.89 | G | 71 | 71 | NL | NL | | | | |
| | 25.03.89 | G | 71 | 71 | 34 | >100 | | | | |
| Huntsville | 06.12.89 | C | 14 | NL | 14 | NL | 84 | NL | >100 | NL |
| | 07.12.89 | C | 21 | NL | 7 | NL | >100 | NL | >100 | NL |
| | 08.12.89 | C | 24 | >100 | 7 | 54 | 84 | NL | >100 | NL |
| | 09.12.89 | C | 28 | 98 | 14 | 66 | 84 | NL | 39 | NL |
| Lindsay | 29.03.89 | C | 96 | | NL | | 71 | 67 | 71 | NL |
| | 30.03.89 | C | 63 | | NL | | 71 | 70 | 14 | NL |
| | 31.03.89 | C | 71 | | NL | | 39 | 100 | 71 | 75 |
| | 01.04.89 | C | 71 | | >100 | | 39 | 93 | >100 | NL |
| | 29.03.89 | G | 67 | | NL | | | | | |
| | 30.03.89 | G | 100 | | NL | | | | | |
| | 31.03.89 | G | 71 | | NL | | | | | |

Table 3.1 Summary of Toxicity Test Results - Cold Weather Conditions

| STP | Date Sample Collected (dd.mm.yy) | Sample Type | Rainbow Trout LC50 (%v/v) | | Daphnia magna LC50 (%v/v) | | Fathead Minnow | | Ceriodaphnia | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | Chronic Value (%v/v) | LC50 (%v/v) | Chronic Value (%v/v) | LC50 (%v/v) |
| Midland | 10.01.90 | C | NL | | NL | | 59 | 98 | 84 | NL |
| | 11.01.90 | C | 66 | | NL | | 14 | NL | 39 | 72 |
| | 12.01.90 | C | 81 | | NL | | 84 | NL | 24 | 38 |
| | 13.01.90 | C | >100 | | NL | | 84 | NL | 59 | 78 |
| | 10.01.90 | G | NL | | NL | | | | | |
| | 11.01.90 | G | 87 | | NL | | | | | |
| | 12.01.90 | G | 97 | | NL | | | | | |
| | 12.01.90 | G | 80 | | NL | | | | | |
| | 12.01.90 | G | >100 | | NL | | | | | |
| | 13.01.90 | G | >100 | | NL | | | | | |
| North Toronto | 15.03.89 | C | NL | NL | NL | NL | >100 | NL | >100 | NL |
| | 16.03.89 | C | NL | NL | NL | NL | 71 | NL | 39 | 94 |
| | 17.03.89 | C | NL | NL | NL | NL | >100 | NL | 71 | NL |
| | 18.03.89 | C | NL | NL | 67 | NL | >100 | NL | 71 | NL |
| Perth | 21.02.90 | C | 54 | | NL | | 39 | NL | 59 | NL |
| | 22.02.90 | C | 98 | | NL | | 59 | NL | 24 | 31 |
| | 23.02.90 | C | 75 | | NL | | 39 | NL | 39 | NL |
| | 24.02.90 | C | 78 | | NL | | 39 | NL | 39 | 24 |
| | 21.02.90 | G | 59 | | NL | | | | | |
| | 22.02.90 | G | 57 | | NL | | | | | |
| | 23.02.90 | G | 18 | | NL | | | | | |
| Stratford | 14.02.90 | C | >100 | | NL | | 59 | NL | 59 | NL |
| | 15.02.90 | C | 87 | | NL | | 59 | NL | 84 | NL |
| | 16.02.90 | C | 84 | | NL | | 14 | NL | 84 | NL |
| | 17.02.90 | C | 84 | | NL | | 84 | NL | 24 | 30 |

Table 3.1 Summary of Toxicity Test Results - Cold Weather Conditions

| STP | Date Sample Collected (dd.mm.yy) | Sample Type | Rainbow Trout LC50 (%v/v) As Received | Rainbow Trout LC50 (%v/v) Dechlorinated | Daphnia magna LC50 (%v/v) As Received | Daphnia magna LC50 (%v/v) Dechlorinated | Fathead Minnow Chronic Value (%v/v) | Fathead Minnow LC50 (%v/v) | Ceriodaphnia Chronic Value (%v/v) | Ceriodaphnia LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|
| Walkerton | 17.01.90 | C | NL | | NL | | 39 | NL | 14 | 39 |
| | 18.01.90 | C | NL | | NL | | >100 | NL | 24 | 33 |
| | 19.01.90 | C | NL | | NL | | >100 | NL | 24 | 67 |
| | 20.01.90 | C | NL | | NL | | >100 | NL | 24 | 63 |
| Wallaceburg | 24.01.90 pH | C | 57 | 73 | 66 | NL | >100 | NL | >100 | NL |
| | 25.01.90 pH | C | 42 | 56 | NL | NL | 84 | NL | 59 | 84 |
| | 26.01.90 pH | C | 39 | | NL | | 84 | NL | >100 | NL |
| | 27.01.90 pH | C | 58 | 81 | NL | NL | >100 | NL | >100 | NL |
| | 24.01.90 | G | 51 | 78 | 59 | NL | | | | |
| | 25.01.90 | G | 44 | 54 | 24 | NL | | | | |
| | 26.01.90 | G | 78 | | NL | | | | | |
| | 26.01.90 | G | 59 | | NL | | | | | |
| | 26.01.90 | G | 72 | 58 | NL | NL | | | | |
| | 27.01.90 | G | 37 | 66 | 14 | NL | | | | |

C - composite
G - grab
pH - sample pH adjusted to 6.0 prior to initiation of chronic tests

Table 3.2 Summary of Toxicity Test Results - Warm Weather Conditions

| STP | Date Sample Collected (dd.mm.yy) | Sample Type | Rainbow Trout LC50 (%v/v) As Received | Rainbow Trout LC50 (%v/v) Dechlorinated | Daphnia magna LC50 (%v/v) As Received | Daphnia magna LC50 (%v/v) Dechlorinated | Fathead Minnow Chronic Value (%v/v) | Fathead Minnow LC50 (%v/v) | Ceriodaphnia Chronic Value (%v/v) | Ceriodaphnia LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|
| Bracebridge | 26.07.89 | C | 99 | | 59 | | >100 | NL | >100 | NL |
| | 27.07.89 | C | NL | | 84 | | >100 | NL | >100 | NL |
| | 28.07.89 | C | NL | NL | 84 | 84 | 84 | NL | >100 | NL |
| | 29.07.89 | C | NL | | NL | | >100 | NL | >100 | NL |
| Highland Creek | 07.06.89 | C | NL | | NL | | <10 | NL | 7 | ** |
| | 08.06.89 | C | >100 | | NL | | 39 | NL | 84 | 100 |
| | 09.06.89 | C | NL | | NL | | 39 | NL | 39 | 32 |
| | 10.06.89 | C | NL | | 18 | | <10 | NL | 1.4 | 5.9 |
| | 07.06.89 | G | >100 | | NL | | | | | |
| | 08.06.89 | G | >100 | | NL | | | | | |
| | 09.06.89 | G | >100 | | 78 | | | | | |
| | 10.06.89 | G | >100 | | 39 | | | | | |
| Huntsville | 16.08.89 | C | 28 | NL | 14 | NL | 24 | NL | >100 | NL |
| | 17.08.89 pH | C | 27 | 78 | >100 | 42 | >100 | NL | 84 | NL |
| | 18.08.89 | C | 37 | NL | 14 | 84 | 14 | NL | >100 | NL |
| | 19.08.89 | C | 39 | NL | 14 | NL | 59 | NL | >100 | NL |
| Lindsay | 23.06.89 | C | NL | | NL | | >100 | NL | >100 | NL |
| | 24.08.89 | C | NL | | NL | | 24 | NL | >100 | NL |
| | 25.08.89 | C | NL | | NL | | >100 | NL | >100 | NL |
| | 26.08.89 | C | NL | | NL | | >100 | NL | >100 | NL |
| | 23.08.89 | G | >100 | | NL | | | | | |
| | 24.08.89 | G | NL | | NL | | | | | |
| | 25.08.89 | G | NL | | NL | | | | | |

Table 3.2 Summary of Toxicity Test Results - Warm Weather Conditions

| STP | Date Sample Collected (dd.mm.yy) | Sample Type | Rainbow Trout LC50 (%v/v) As Received | Rainbow Trout LC50 (%v/v) Dechlorinated | Daphnia magna LC50 (%v/v) As Received | Daphnia magna LC50 (%v/v) Dechlorinated | Fathead Minnow Chronic Value (%v/v) | Fathead Minnow LC50 (%v/v) | Ceriodaphnia Chronic Value (%v/v) | Ceriodaphnia LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|
| Midland | 19.07.89 | C | 50 | 83 | 19 | 84 | 84 | NL | >100 | NL |
| | 20.07.89 | C | 60 | >100 | 21 | 63 | 59 | 88 | 59 | 67 |
| | 21.07.89 | C | 75 | | 92 | | >100 | NL | >100 | NL |
| | 22.07.89 | C | 84 | >100 | NL | NL | 84 | 100 | 39 | 86 |
| | 19.07.89 | G | 29 | >100 | 14 | NL | | | | |
| | 20.07.89 | G | 39 | >100 | 24 | 98 | | | | |
| | 21.07.89 | G | 31 | NL | 14 | NL | | | | |
| | 21.07.89 | G | 68 | 75 | NL | NL | | | | |
| | 21.07.89 | G | 73 | 84 | >100 | NL | | | | |
| | 22.07.89 | G | 71 | 100 | 75 | NL | | | | |
| North Toronto | 14.06.89 | C | 59 | NL | 22 | NL | 84 | NL | >100 | NL |
| | 15.06.89 | C | 42 | NL | 14 | >100 | >100 | NL | >100 | NL |
| | 16.06.89 | C | 57 | NL | 39 | NL | 84 | NL | >100 | NL |
| | 17.06.89 | C | >100 | >100 | 73 | NL | <10 | NL | >100 | NL |
| Perth | 13.09.89 | C | NL | | NL | | 84 | NL | >100 | NL |
| | 14.09.89 | C | NL | | NL | | 84 | NL | >100 | NL |
| | 15.09.89 | C | NL | | NL | | 39 | NL | >100 | NL |
| | 16.09.89 | C | NL | | NL | | 59 | NL | >100 | NL |
| | 13.09.89 | G | NL | | NL | | | | | |
| | 14.09.89 | G | NL | | NL | | | | | |
| | 15.09.89 | G | NL | | NL | | | | | |
| Stratford | 12.07.89 | C | 63 | | NL | | 24 | 58 | 59 | NL |
| | 13.07.89 | C | 75 | | NL | | 84 | NL | 84 | 94 |
| | 14.07.89 | C | 74 | | NL | | 39 | 97 | 84 | NL |
| | 15.07.89 | C | 51 | | NL | | 39 | 87 | 84 | NL |

Table 3.2 Summary of Toxicity Test Results - Warm Weather Conditions

| STP | Date Sample Collected (dd.mm.yy) | Sample Type | Rainbow Trout LC50 (%v/v) | | Daphnia magna LC50 (%v/v) | | Fathead Minnow | | Ceriodaphnia | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | Chronic Value (%v/v) | LC50 (%v/v) | Chronic Value (%v/v) | LC50 (%v/v) |
| Walkerton | 21.06.89 | C | ** | ** | NL | NL | >100 | NL | 59 | 77 |
| | 22.06.89 | C | >100 | | NL | | >100 | NL | 59 | 94 |
| | 23.06.89 | C | NL | | NL | | >100 | NL | 84 | NL |
| | 24.06.89 | C | NL | | NL | | >100 | NL | 84 | 100 |
| Wallaceburg | 06.09.89 | C | NL | >100 | 81 | NL | 24 | NL | >100 | NL |
| | 07.09.89 | C | NL | NL | NL | NL | 59 | NL | >100 | NL |
| | 08.09.89 | C | NL | | NL | | 84 | NL | >100 | NL |
| | 09.09.89 pH | C | 84 | | >100 | | >100 | NL | >100 | NL |
| | 06.09.89 | G | NL | | NL | | | | | |
| | 07.09.89 | G | NL | NL | NL | NL | | | | |
| | 08.09.89 | G | 84 | NL | 59 | NL | | | | |
| | 08.09.89 | G | 78 | | NL | | | | | |
| | 08.09.89 | G | NL | | NL | | | | | |
| | 09.09.89 | G | NL | NL | 54 | NL | | | | |

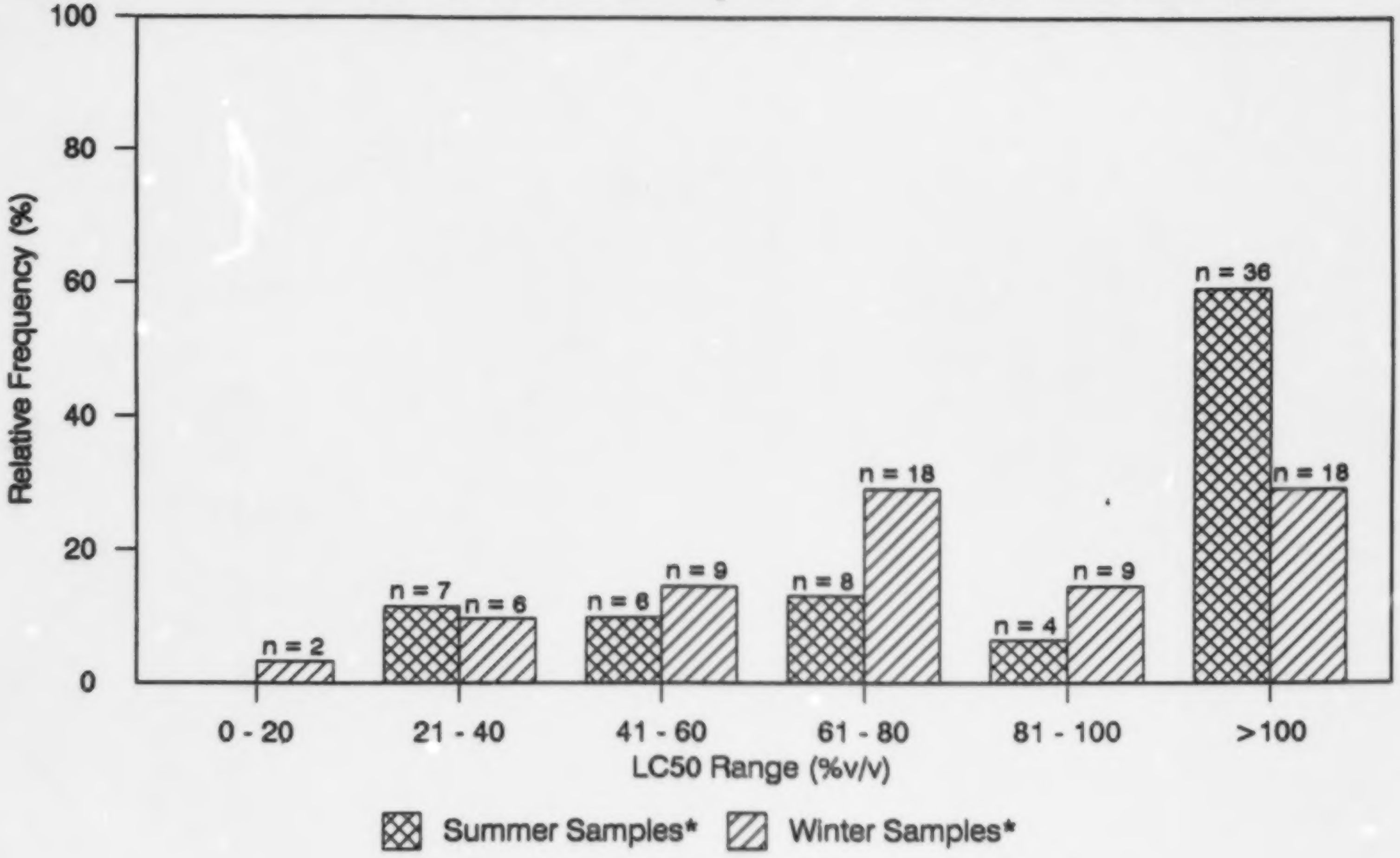
C - composite
G - grab
pH - sample pH adjusted to 6.0 prior to initiation of chronic tests
** - invalid data

## TABLE 3.3: PERCENT ACUTELY LETHAL STP EFFLUENT SAMPLES (combined grab and composite sample results)

|  | Lethal Samples |  |  |  |
|---|---|---|---|---|
|  | Rainbow Trout |  | Daphnia magna |  |
|  | No. | As Percent[a] | No. | As Percent |
| **Summer** |  |  |  |  |
| All Samples As Received | 25 | 41 | 23 | 37 |
| Samples with Initial TRC  0.1 mg/L: |  |  |  |  |
| o As Received | 17 | 74 | 17 | 71 |
| o Dechlorinated | 5 | 22 | 6 | 25 |
| **Winter** |  |  |  |  |
| All Samples As Received | 44 | 71 | 11 | 18 |
| Samples with Initial TRC  0.1 mg/L: |  |  |  |  |
| o As Received | 16 | 80 | 11 | 55 |
| o Dechlorinated | 13 | 65 | 2 | 10 |
| **Winter and Summer Data Combined** |  |  |  |  |
| All Samples As Received | 69 | 56 | 34 | 27 |
| Samples with Initial TRC  0.1 mg/L: |  |  |  |  |
| o As Received | 33 | 77 | 28 | 64 |
| o Dechlorinated | 18 | 42 | 8 | 18 |

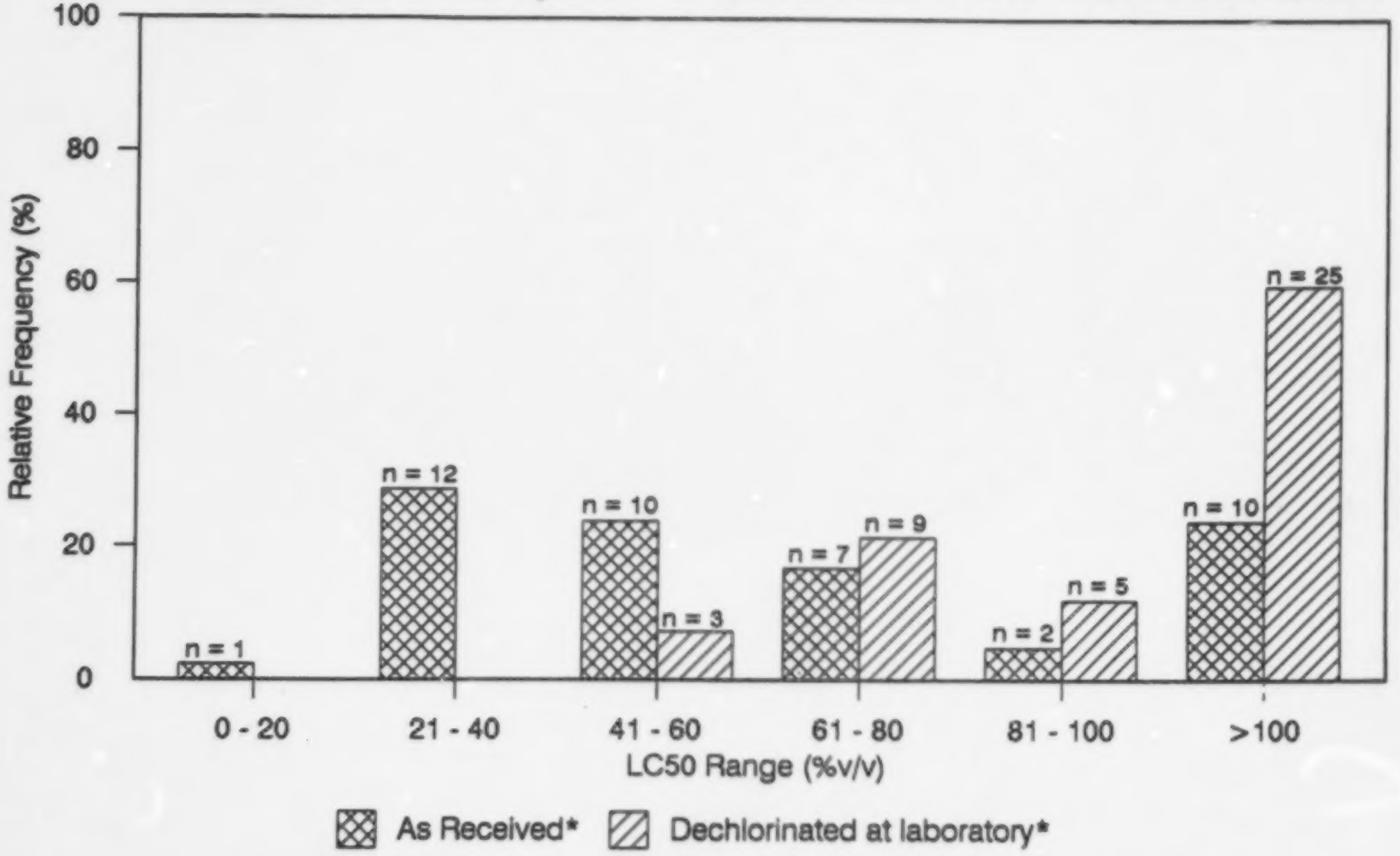
[a] Of total samples tested in that group.

**Figure 3.1 Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Summer vs. Winter**



* includes composite & grab samples - as received
n - number of samples

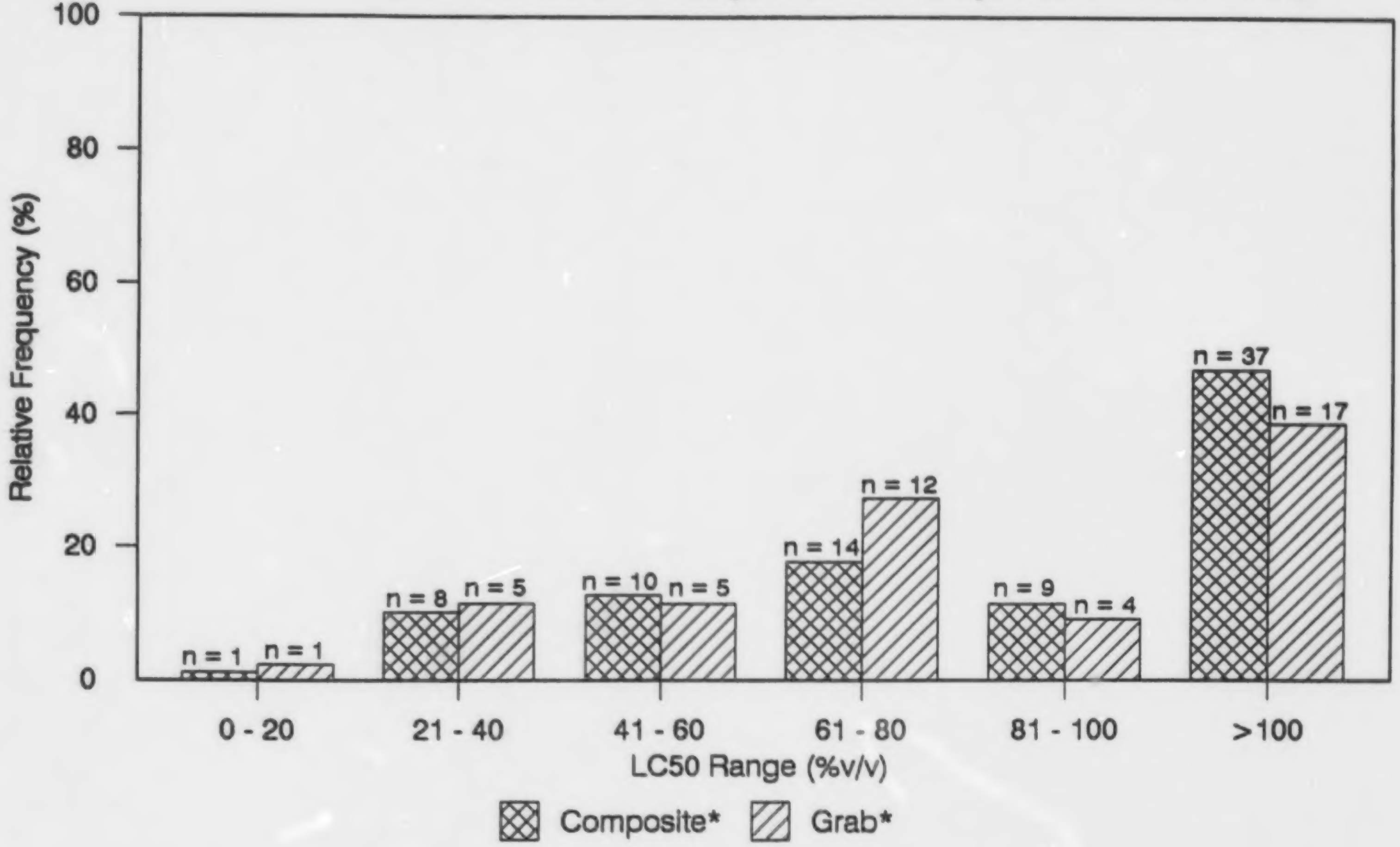
Figure 3.2 Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Before and After Dechlorination



* includes composite and grab samples collected in summer and winter that showed TRC > 0.1 mg/L when received at toxicity laboratory

n - number of samples

## Figure 3.3 Relative Distribution of Rainbow Trout LC50's for Effluent Samples - Composite vs. Grab



* includes samples collected in summer and winter (as received)
n - number of samples

consistently non-lethal effluents in summer (Lindsay, Perth, Stratford, Walkerton) (Tables 3.1, 3.2 and Appendix E). In contrast to trout test results, D. magna tests indicated that samples collected in the winter were less toxic (18% lethal samples, tested as received) than those collected in the summer (37% lethal samples) (Table 3.3). The distribution of LC50s for samples tested as received was generally similar for summer versus winter (Figure 3.4; also see Section 4.1.3).

Dechlorination of samples which initially contained TRC concentrations of 0.1 mg/L or more reduced the percentage of lethal samples from 55% to 10% in winter and from 71% to 25% in summer (Table 3.3). LC50s as low as 7% were observed for samples tested prior to dechlorination, in contrast to dechlorinated samples which showed LC50s of greater than 40% (Figure 3.5; also see Section 4.4.4).

Composite and grab samples showed similar LC50 distributions (Figure 3.6; also see Section 4.1.2).

### 3.1.2 Chronic Toxicity

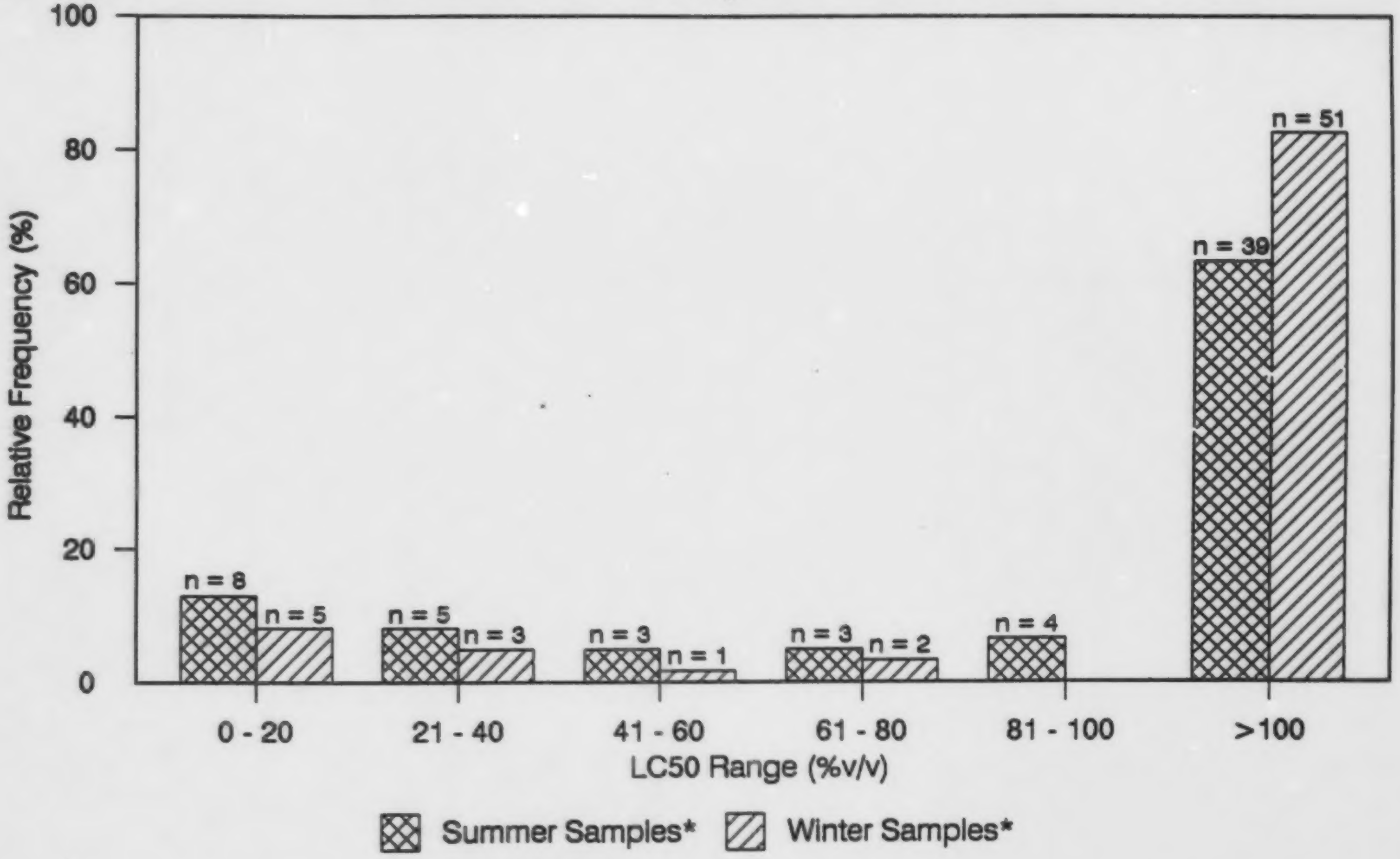
As discussed in section 2.5, chronic tests were performed on composite samples only. If the sample was split for dechlorination (i.e., TRC greater than or equal to 0.1 mg/L), chronic tests were initiated on the dechlorinated portion of the sample only. If the concentration of un-ionized ammonia was 0.1 mg/L or greater and was associated with more than 20% mortality in the first 24 hours of the rainbow trout test, the sample pH was adjusted to 6.0 prior to test initiation. These sample treatments were intended to reduce or remove acute lethal effects attributable to TRC and ammonia.

#### 3.1.2.1 Fathead Minnow Larval Survival and Growth Impairment

Chronic lethality to fathead minnows was observed in effluent samples from two STPs during summer (Midland, Stratford) and three STPs during winter (Highland Creek, Lindsay, Midland) (Tables 3.1, 3.2). All fathead minnow 7-day LC50s were greater than 50% and little difference was observed between winter and summer samples (Figure 3.7).

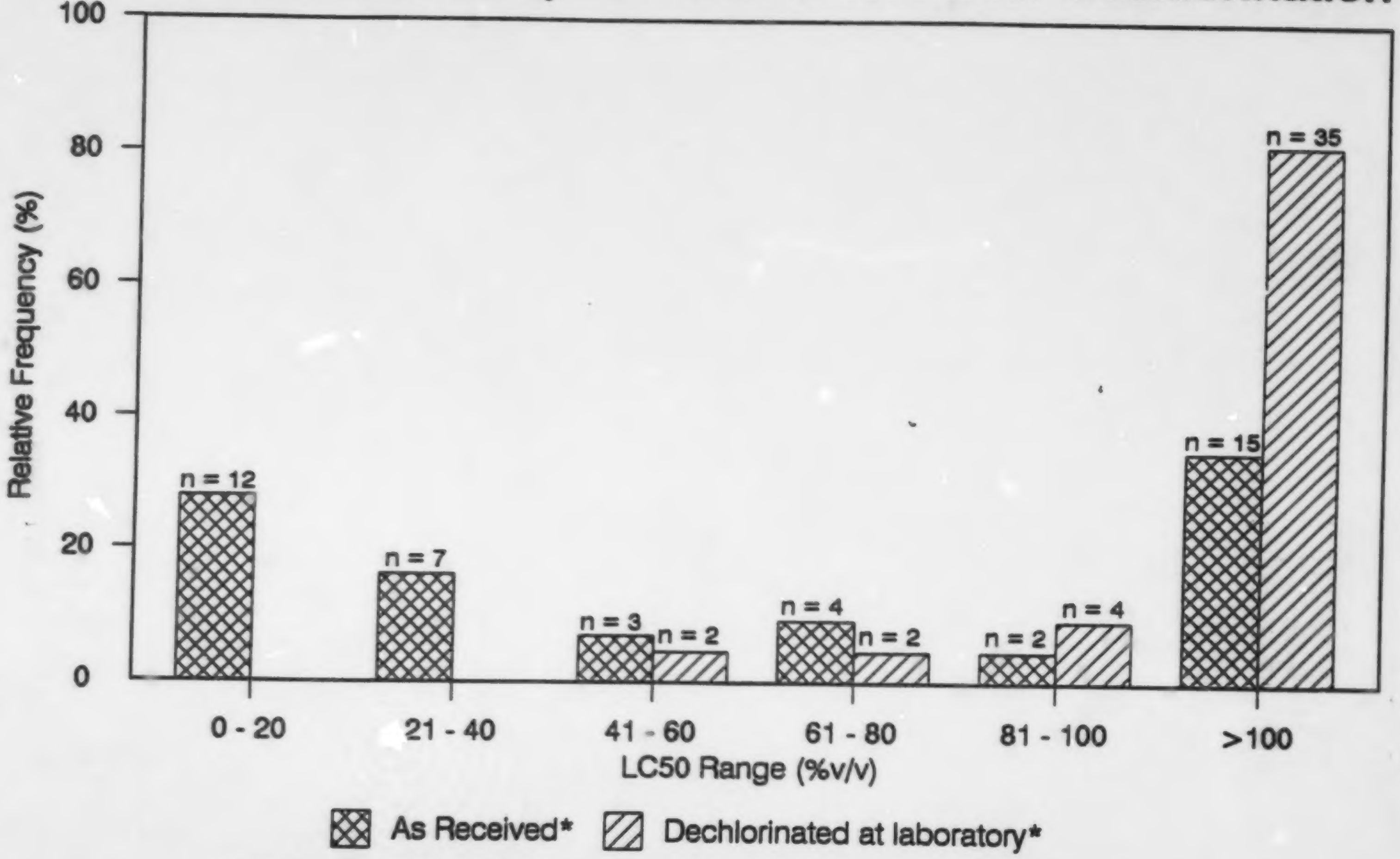
Impairment of fathead minnow growth occurred in 69% of all samples tested (Table 3.4). None of the STPs sampled produced effluent samples that consistently showed no

# Figure 3.4 Relative Distribution of Daphnia magna LC50's for Effluent Samples - Summer vs. Winter



* includes composite & grab samples - as received
n - number of samples

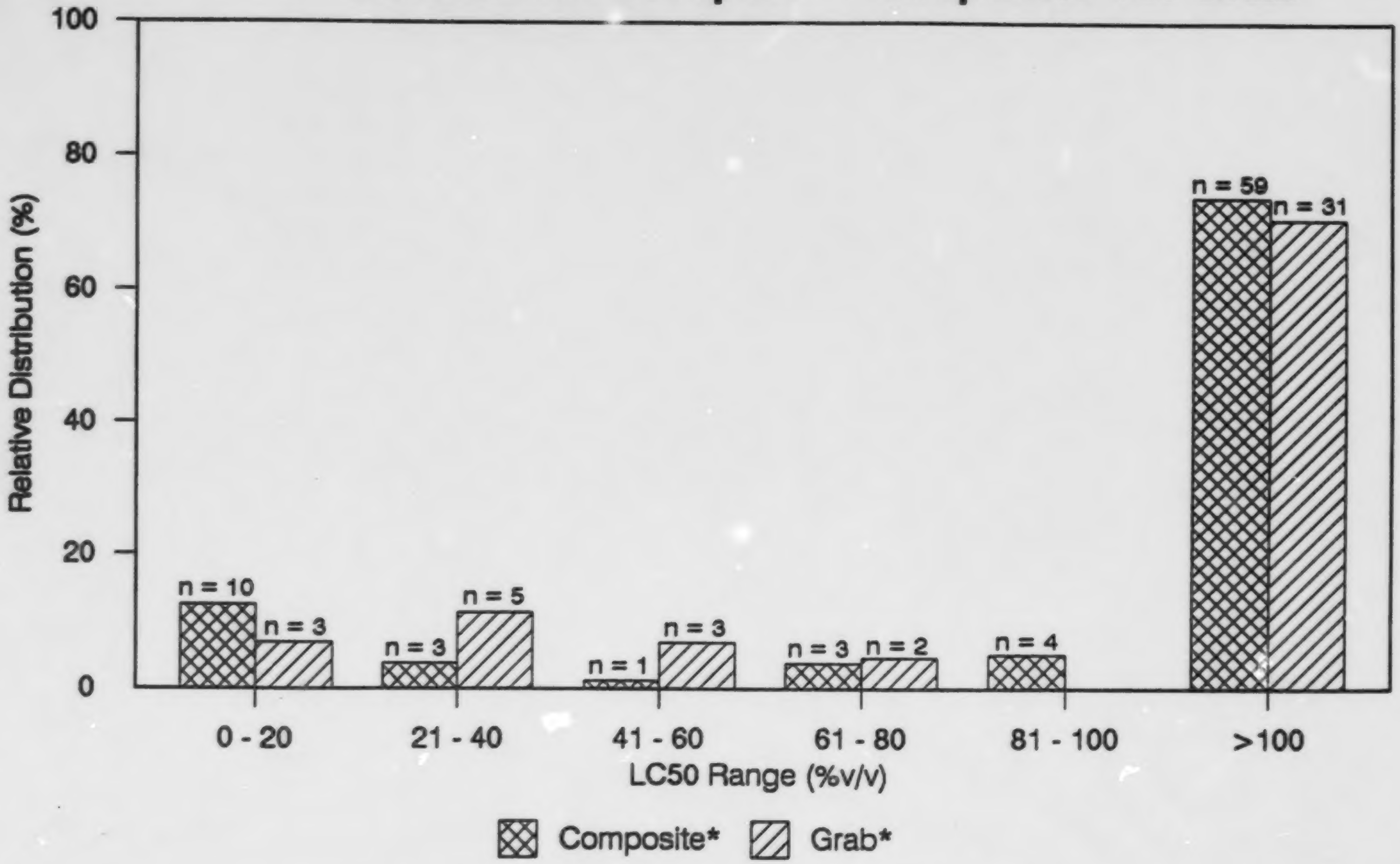
## Figure 3.5 Relative Distribution of *Daphnia magna* LC50's for Effluent Samples - Before and After Dechlorination



* includes composite and grab samples collected in summer and winter that showed TRC > 0.1 mg/L when received at toxicity laboratory

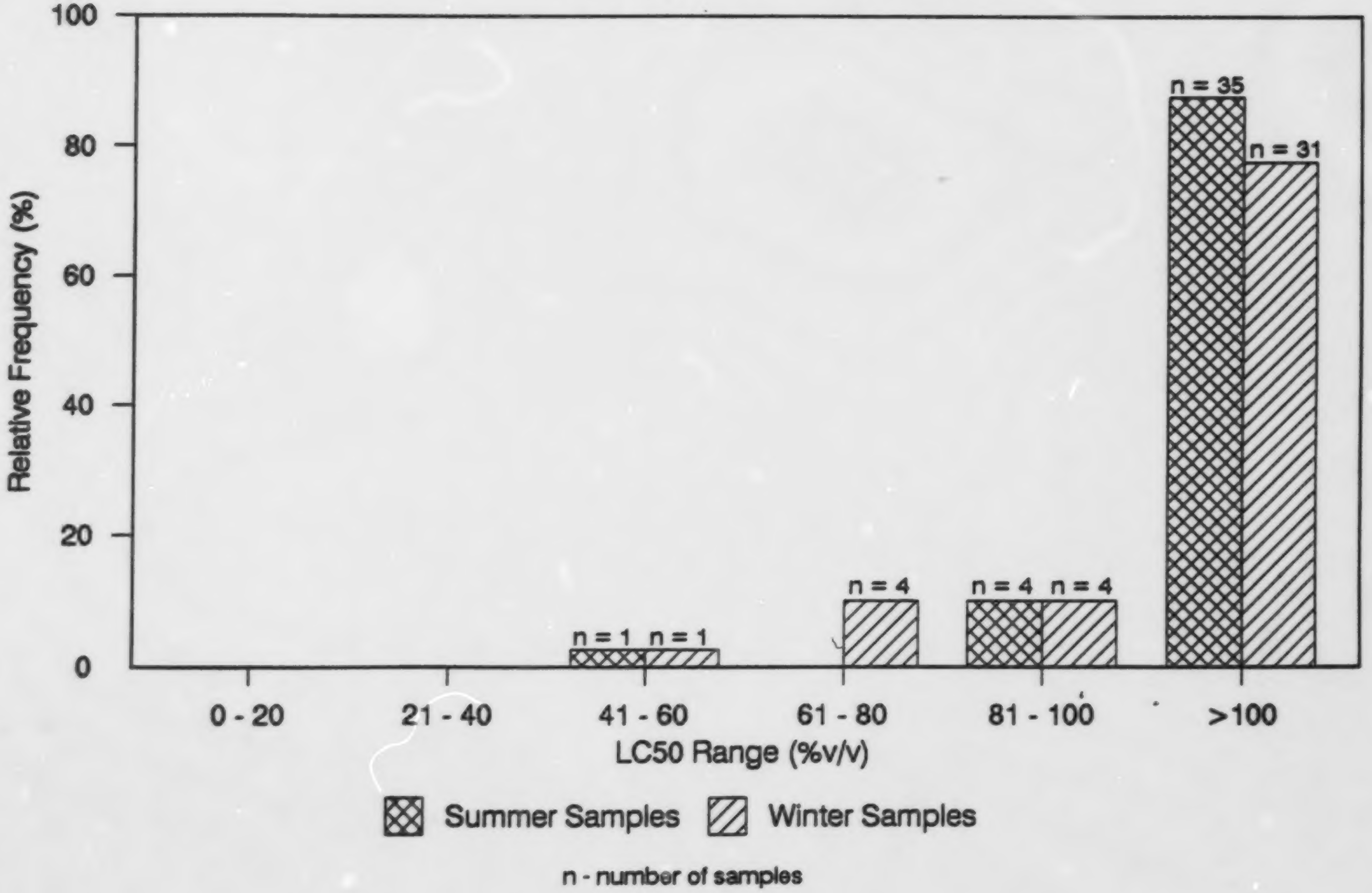
n - number of samples

## Figure 3.6 Relative Distribution of Daphnia magna LC50's for Effluent Samples - Composite vs. Grab



* includes samples collected in summer and winter (as received)
n - number of samples

Figure 3.7 Relative Distribution of Fathead Minnow Chronic LC50's for Composite Effluent Samples- Summer vs. Winter



## TABLE 3.4: SAMPLES[a] WHICH PRODUCED CHRONIC LETHAL OR SUBLETHAL EFFECTS ON FATHEAD MINNOWS[b] OR *C. DUBIA*[c]

| | Lethal | | Sublethal Effect | |
|---|---|---|---|---|
| | No. Samples | As Percent | No. Samples | As Percent |
| **Summer** | | | | |
| Fathead minnow | 5 | 13 | 26 | 65 |
| *C. dubia* | 9 | 23 | 15 | 38 |
| **Winter** | | | | |
| Fathead minnow | 9 | 23 | 29 | 73 |
| *C. dubia* | 15 | 38 | 30 | 75 |
| **Summer and Winter** | | | | |
| Fathead minnow | 14 | 18 | 55 | 69 |
| *C. dubia* | 24 | 30 | 45 | 56 |

[a] Some samples were treated (dechlorinated, pH-adjusted) to reduce TRC and un-ionized ammonia below the concentration that would be likely to cause acute lethality (see text).

[b] 7-day exposure.

[c] 7- to 8-day exposure.

sublethal effect; in summer, only Walkerton's effluent was consistently non-toxic and, in winter, none of the STPs consistently produced a non-toxic effluent (Tables 3.1, 3.2). Threshold effect concentrations (chronic value) ranged as low as 14% effluent, with little difference observed between the distribution of chronic values in summer versus winter (Figure 3.8; see also Section 4.1.3).

### 3.1.2.2 Ceriodaphnia dubia Survival and Reproductive Impariment

Six STPs produced effluent samples which were non-lethal to C. dubia during the summer (Bracebridge, Huntsville, Lindsay, North Toronto, Perth, Wallaceburg), while the effluent from only one plant (Huntsville) was consistently non-lethal during the winter. The proportion of lethal samples was 38% during the winter, compared to 23% during summer sampling (Table 3.4). C. dubia 7-day LC50s ranged as low as 6% effluent (Table 3.1, Figure 3.9).

While no sublethal effects were observed in summer samples from Bracebridge, Lindsay, North Toronto, Perth, and Wallaceburg, all STPs produced at least one sample that resulted in reproductive impairment of C. dubia during the winter (Table 3.1, 3.2). Substantially more winter samples caused reproductive impairment of C. dubia (75%) relative to summer samples (also see Section 4.1.3). Chronic values for all samples ranged as low as 1.4% effluent (Figure 3.10). More than half of all samples tested (56%) resulted in sublethal toxicity to C. dubia (Table 3.4).

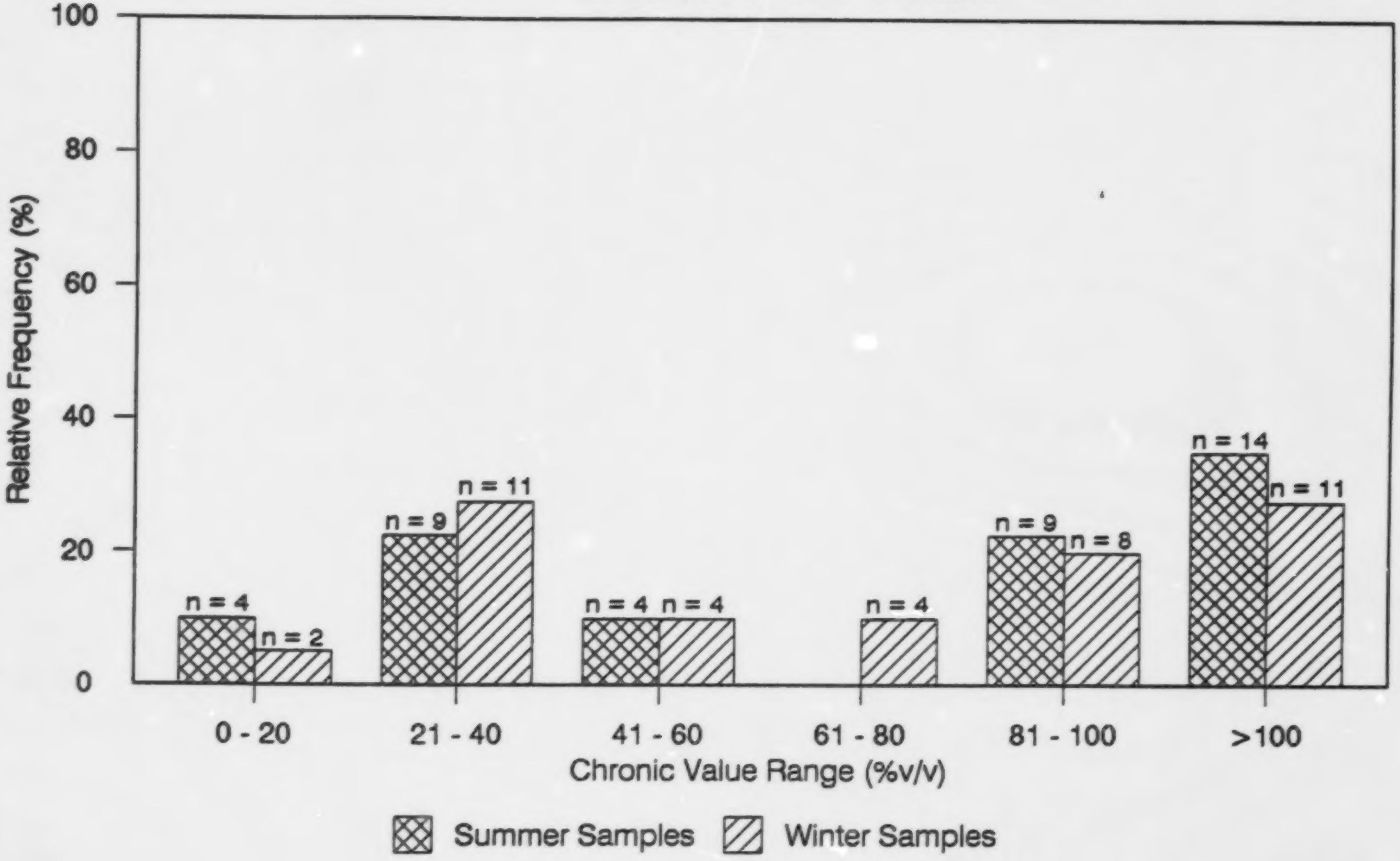
## 3.2 Effluent Chemistry

The detailed results of analyses conducted on composite and grab samples of effluent collected from the ten STPs during the summer and winter sampling periods are presented in Appendix F. In these tables, concentrations of contaminants present at less than the analytical method detection limit (MDL) have been reported as MDL/2.0 for the purposes of calculating averages and standard deviations.

### 3.2.1 Summer Samples

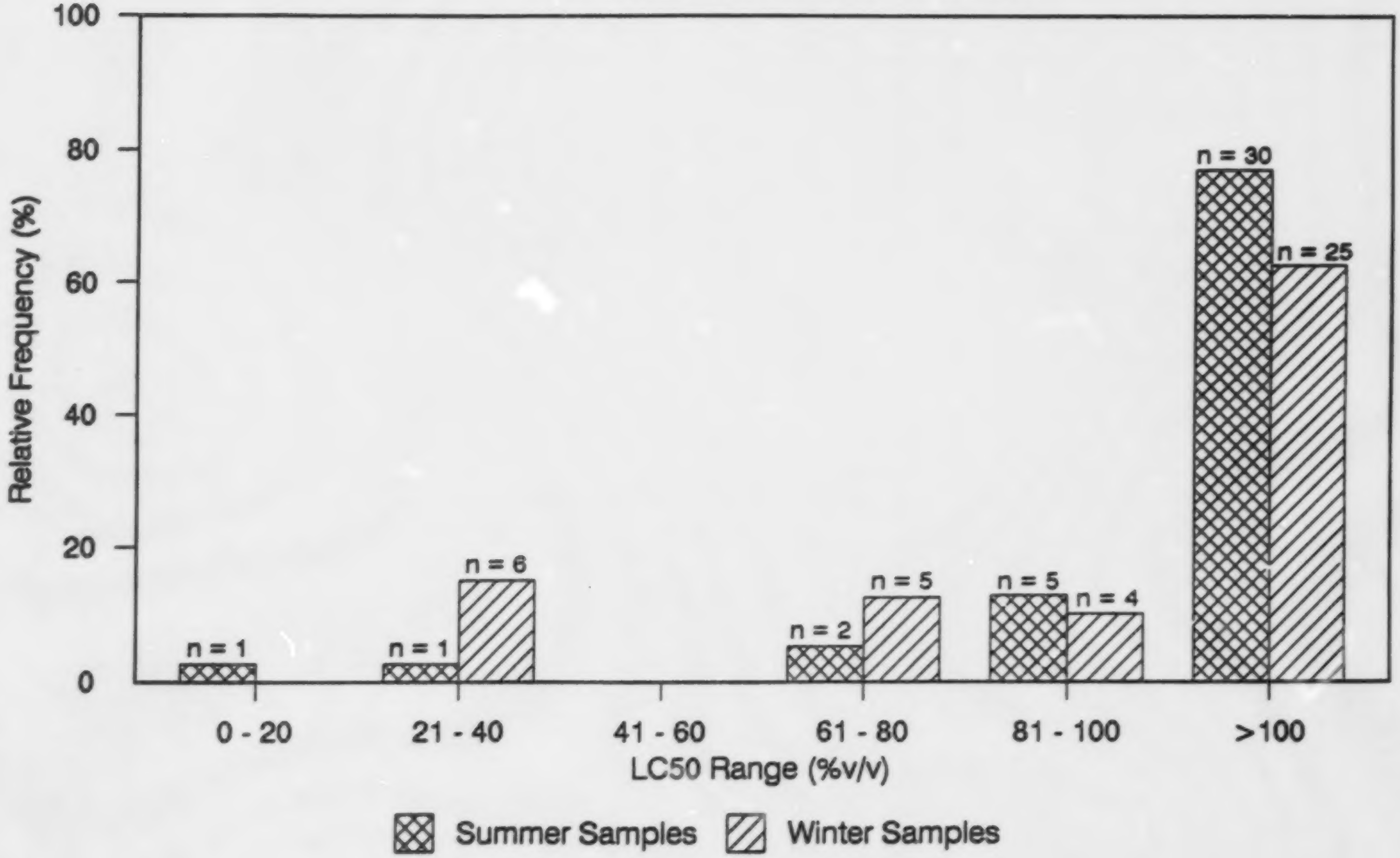
Table 3.5 summarizes the average concentrations of conventional contaminants and filtered and unfiltered metals in the effluents from the ten STPs during the summer sampling period based on the composite samples.

Figure 3.8 Relative Distribution of Fathead Minnow Chronic Values for Composite Effluent Samples - Summer vs. Winter



n - number of samples

Figure 3.9 Relative Distribution of C. dubia Chronic LC50's for Composite Effluent Samples - Summer vs. Winter



n - number of samples

Figure 3.10 Relative Distribution of C. dubia Chronic Values for Composite Effluent Samples - Summer vs. Winter

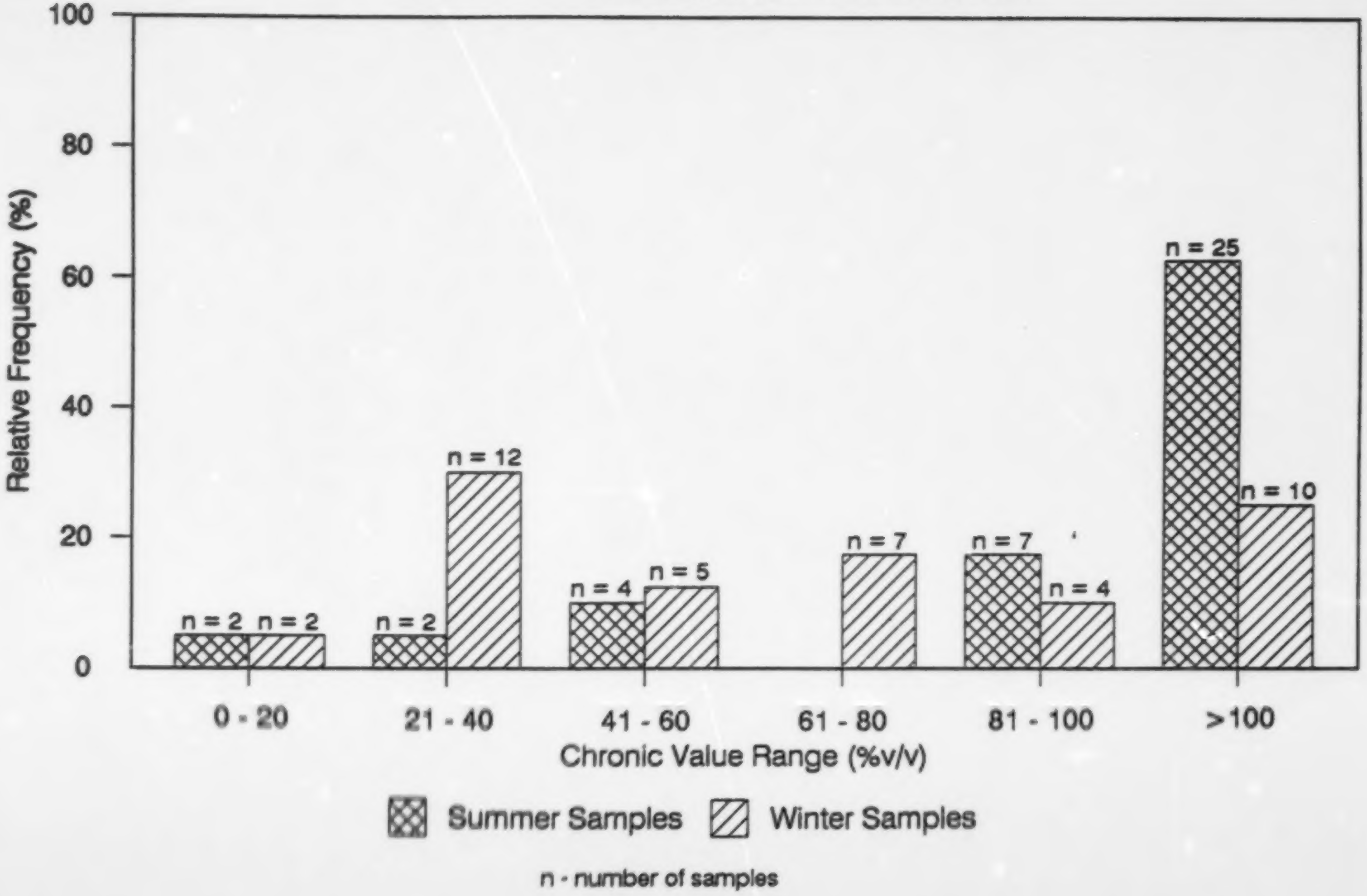


Table 3.5 Average Concentrations of Conventional Contaminants and Metals in Composite Samples of Effluents During Summer Sampling Program

| | BRACEBRIDGE | HIGHLAND CREEK | HUNTSVILLE | LINDSAY | MIDLAND | NORTH TORONTO | PERTH | STRATFORD | WALKERTON | WALLACEBURG |
|---|---|---|---|---|---|---|---|---|---|---|
| BOD | 2.3 | 42.7 | 4.1 | 17.1 | 8.0 | 4.4 | 2.6 | 20.9 | 4.1 | 10.8 |
| DOC | 8.3 | 11.8 | 10.1 | 14.1 | 5.0 | 5.7 | 8.8 | 6.4 | 4.3 | 14.9 |
| SS | 4.3 | 27.0 | 8.1 | 33.1 | 7.2 | 8.6 | 4.6 | 3.9 | 12.4 | 3.9 |
| VSS | 3.2 | 21.8 | 6.0 | 26.8 | 4.0 | 5.2 | 3.8 | 2.8 | 10.6 | 3.9 |
| NH3-N | 4.07 | 11.51 | 16.03 | 1.62 | 12.64 | 3.48 | 4.92 | 15.34 | 0.09 | 6.44 |
| NO3-N | 3.40 | 4.90 | 0.34 | 0.22 | 0.41 | 14.46 | <0.06 | 2.15 | 15.35 | 7.83 |
| NO2-N | 0.015 | 3.025 | 0.063 | 0.188 | 0.219 | 0.505 | 0.005 | 1.096 | 0.076 | 1.100 |
| Sulphide | NA | NA | NA | <0.05 | NA | NA | <0.05 | NA | NA | NA |
| TRC | 0.07 | <0.01 | 0.53 | <0.01 | 0.26 | 0.31 | <0.01 | <0.01 | 0.04 | 0.081 |
| | | | | | | | | | | |
| Ag - T | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Ag - F | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Al - T | 0.4150 | 0.2750 | 0.8000 | 0.0838 | 0.1313 | 0.0325 | 0.0500 | 0.1075 | 0.0925 | <0.02 |
| Al - F | 0.1175 | 0.0263 | 0.1875 | 0.0275 | 0.0738 | <0.02 | 0.0619 | 0.1150 | 0.1913 | 0.0175 |
| As - T | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0231 | <0.01 |
| As - F | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0175 | <0.01 |
| Be - T | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Be - F | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Ca - T | 2.10 | 195.98 | 17.67 | 50.94 | 2.54 | 173.85 | 66.5000 | 0.26 | 369.25 | 72.13 |
| Ca - F | 1.96 | 186.00 | 22.46 | 49.18 | 1.86 | 176.60 | 64.45 | 0.24 | 200.00 | 65.50 |
| Cd - T | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cd - F | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Co - T | <0.005 | <0.005 | 0.0051 | <0.005 | 0.0056 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Co - F | <0.005 | <0.005 | <0.005 | 0.0259 | 0.0061 | <0.005 | <0.01 | <0.005 | <0.005 | <0.005 |
| Cr - T | <0.005 | 0.0141 | 0.0114 | <0.005 | 0.0049 | <0.005 | <0.005 | <0.005 | <0.005 | 0.0074 |
| Cr - F | 0.0131 | 0.0048 | 0.0066 | <0.005 | <0.005 | <0.005 | <0.01 | 0.0231 | <0.005 | 0.0065 |
| Cu - T | 0.0152 | 0.0458 | <0.005 | 0.0035 | 0.0045 | 0.0118 | 0.0221 | <0.005 | 0.0355 | 0.0375 |
| Cu - F | 0.0067 | 0.0274 | 0.0082 | 0.0055 | 0.0050 | 0.0320 | 0.0245 | 0.0051 | 0.0315 | 0.0568 |
| Fe - T | 0.2125 | 2.6325 | 0.5073 | 0.2800 | 0.3963 | 0.8975 | 0.1285 | 0.1849 | 0.2725 | 0.3275 |
| Fe - F | 0.1005 | 0.0843 | 0.2800 | 0.0713 | 0.0235 | 0.0842 | 0.1230 | 0.1038 | 0.1365 | 0.1058 |
| Hg - T (ug/L) | <0.01 | 0.1038 | 0.0275 | 0.0125 | 0.0513 | 0.0400 | <0.01 | <0.01 | 0.0194 | 0.0125 |
| Hg - F (ug/L) | 0.0156 | 0.2125 | 0.0413 | 0.0381 | 0.0600 | 0.0300 | 0.0475 | 0.0675 | 0.0306 | 0.0500 |
| Mg - T | 4.38 | 10.03 | 3.54 | 10.63 | 13.25 | 10.30 | 14.7500 | 25.38 | 23.05 | 11.38 |
| Mg - F | 4.44 | 10.03 | 4.25 | 10.98 | 13.25 | 10.40 | 14.13 | 25.75 | 23.25 | 10.88 |
| Mn - T | 0.1325 | 0.7525 | 0.1038 | 0.0425 | 0.0569 | 0.0675 | 0.0788 | 0.0925 | 0.0275 | 0.0825 |
| Mn - F | 0.1325 | 0.7325 | 0.1350 | 0.0075 | 0.0406 | 0.0600 | 0.0798 | 0.0900 | 0.0300 | 0.0775 |
| Mo - T | <0.005 | 0.0093 | <0.005 | 0.0375 | <0.005 | 0.0188 | <0.005 | 0.0265 | 0.0040 | 0.0196 |
| Mo - F | <0.005 | 0.0086 | 0.0639 | 0.0358 | <0.005 | 0.0183 | <0.005 | 0.0275 | <0.005 | 0.0199 |
| Ni - T | <0.01 | 0.0368 | 0.0738 | <0.01 | 0.1606 | 0.0129 | 0.0120 | 0.0248 | 0.0798 | 0.0510 |
| Ni - F | <0.01 | 0.0350 | <0.01 | 0.0065 | 0.1544 | 0.0095 | 0.0116 | 0.0250 | 0.0765 | 0.0578 |
| Pb - T | 0.0181 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0100 | 0.0119 | 0.0096 | 0.0138 |
| Pb - F | 0.0219 | <0.01 | <0.01 | 0.0075 | <0.01 | <0.01 | 0.0131 | <0.01 | 0.0625 | <0.01 |
| Se - T | <0.01 | <0.01 | <0.01 | 0.0175 | <0.01 | 0.0100 | <0.01 | <0.01 | 0.0306 | <0.01 |
| Se - F | <0.01 | <0.01 | <0.01 | 0.0175 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0313 | <0.01 |
| Sr - T | 0.1050 | 0.2025 | 0.0750 | 0.2025 | 0.1644 | 0.2050 | 0.4700 | 7.29 | 4.7000 | 0.2475 |
| Sr - F | 0.1075 | 0.2025 | 0.0975 | 0.2025 | 0.1656 | 0.1528 | 0.4725 | 7.5500 | 4.5000 | 0.2275 |
| V - T | <0.02 | <0.06 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| V - F | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Zn - T | 0.0275 | 0.1000 | 0.0213 | 0.0106 | 0.0506 | 0.0225 | 0.0150 | 0.0525 | 0.0775 | 0.0475 |
| Zn - F | 0.0350 | 0.1063 | 0.0513 | 0.0250 | 0.0444 | 0.0250 | 0.0106 | 0.0300 | 0.0900 | 0.0525 |

Note: T = Total (Unfiltered) Metal Concentration
F = Filtered Metal Concentration
NA = Not Analyzed

All concentrations reported in mg/L, except as noted.

In general, the performance of the ten STPs during summer sampling was consistent with their historical performance (Appendix A) based on concentrations of $BOD_5$ and suspended solids in the final effluents. Of the secondary and tertiary plants, only one (Walkerton) achieved complete nitrification during the summer period. At the Walkerton plant, total effluent ammonia concentrations of less than 0.1 mg/L were achieved and the complete conversion to nitrate was apparent from the low nitrite concentration ( 0.1 mg/L) in the effluent. The Bracebridge, North Toronto and Wallaceburg plants achieved partial nitrification to effluent ammonia levels less than 10 mg/L $NH_3$-N. The other four secondary and tertiary STPs (Highland Creek, Huntsville, Midland, and Stratford) produced effluents containing $NH_3$-N concentrations in excess of 10 mg/L; however, the presence of elevated concentrations of nitrate and nitrite in the effluents from both Stratford and Highland Creek suggest that in both instances some nitrification is occurring. In both cases, nitrite represents a substantial fraction of the oxidized nitrogen in the plant effluent which may suggest an inhibition of Nitrobacter due to oxygen limitations or other chemical contaminants. At Huntsville and Midland, there was no indication that nitrification was occurring to even a limited extent.

At the two lagoons (Lindsay and Perth), a high degree of nitrogen removal was apparent during the summer. In both cases, effluent $NH_3$-N concentrations averaged less than 5.0 mg/L. In neither case was there an accumulation of oxidized nitrogen as either nitrate of nitrite indicating that denitrification was occurring under anoxic conditions in these treatment plants. Hydrogen sulphide was not present at detectable concentrations (greater than 0.05 mg/L) in any lagoon sample collected during the summer.

Seven samples were submitted for trace organic contaminant analysis during the summer sampling period. These samples represented effluents from three STPs, namely; Highland Creek (two samples), Huntsville (two samples) and Stratford (three samples). The results of these analyses are presented in Table 3.6. In Table 3.6, only those compounds detected at concentrations above the method detection limit (MDL) have been reported. The samples were analyzed for the semi-volatile EMPPL compounds (acid and base-neutral extractable compounds, pesticides and herbicides).

As evident from Table 3.6, only seven compounds were identified at concentrations above the MDL in any of these samples, including one phthalate ester (BEHP) and six pesticides/herbicides. Only gamma-BHC was detected in all seven samples. BEHP was

TABLE 3.6: CONCENTRATIONS OF TRACE ORGANIC COMPOUNDS DETECTED IN EFFLUENT SAMPLES, SUMMER SAMPLING PROGRAM

| Compound (Concentration) | Highland Creek 07 June | Highland Creek 10 June | Huntsville 16 August | Huntsville 18 August | Stratford 13 July | Stratford 13 July | Stratford 15 July |
|---|---|---|---|---|---|---|---|
| Bis-2-ethylhexylphthalate (ug/L) | 10 | | | | | 14 | 27 |
| γ-BHC (ng/L) | 10 | 14 | 35 | 27 | 75 | 45 | 65 |
| pp-DDT (ng/L) | 5 | | | | | | |
| Hexachlorobenzene (ng/L) | 2 | | | | | | |
| Heptachlor (ng/L) | 5 | 5 | | | | | |
| 2,4-D-Propionic Acid (ng/L) | | | | 280 | | | |
| 2,4-Dichlorophenoxybutyric Acid (ng/L) | | | | 230 | | | |

detected in three of the seven samples. The other organic compounds were only found in one or two of the samples analyzed.

### 3.2.2 Winter Samples

Table 3.7 summarizes the average concentrations of conventional contaminants and metals in composite samples of the effluents from the ten STPs during the winter sampling period. At most plants, the differences in concentrations between summer and winter samples were minimal in terms of $BOD_5$, suspended solids, and metals concentrations. In STPs where differences were evident, generally effluent quality deteriorated in winter relative to the summer performance. Exceptions were Stratford and Lindsay.

The winter data at Stratford showed a lower $BOD_5$ concentration than the comparative summer data, despite similar DOC concentrations. The difference may relate to a higher nitrogenous oxygen demand in the samples collected in the summer than those collected in the winter since total $BOD_5$ analyses were performed rather than carbonaceous $BOD_5$ analyses. At Lindsay, substantially lower suspended solids concentrations were apparent in the winter samples as a result of the lower level of algal growth in the lagoons under winter conditions. However, effluent quality from the Perth STP, the other lagoon included in the sampling program, was substantially poorer in terms of both BOD5 and suspended solids during winter operation. Effluent quality from the North Toronto STP was substantially poorer during the winter sampling period due to an occurrence of floating scum on the final clarifiers during the winter test program.

Based on the presence of oxidized nitrogen in the effluents from the secondary and tertiary STPs, all of the facilities achieved some degree of nitrification under winter conditions. Bracebridge, North Toronto, and Walkerton achieved near total nitrification, producing average total effluent $NH_3$-N concentrations of about 1.0 mg/L or less. Stratford and Midland produced effluents containing less than 10.0 mg/L $NH_3$-N on average. Although concentrations in effluents from Hunstville, Highland Creek and Wallaceburg were higher than 10.0 mg/L, some nitrification was evident at these plants as well. It had been anticipated that substantially higher effluent ammonia concentrations would be present in effluents under winter conditions due to the lower nitrifier activity at low temperatures. A comparison of mean concentrations between

Table 3.7 Average Concentrations of Conventional Contaminants and Metals in Composite Samples of Effluents During Winter Sampling Program

| | BRACEBRIDGE | HIGHLAND CREEK | HUNTSVILLE | LINDSAY | MIDLAND | NORTH TORONTO | PERTH | STRATFORD | WALKERTON | WALLACEBURG |
|---|---|---|---|---|---|---|---|---|---|---|
| BOD | 5.6 | 30.8 | 0.9 | 16.1 | 26.2 | 19.6 | 30.5 | 10.3 | 6.5 | 11.7 |
| DOC | 6.8 | 14.7 | 8.3 | 14.1 | 4.8 | 6.8 | 13.7 | 5.4 | 4.3 | 17.1 |
| SS | 5.0 | 28.0 | 6.6 | 20.4 | 5.5 | 33.0 | 19.9 | 1.1 | 5.4 | 15.6 |
| VSS | 3.8 | 22.5 | 5.5 | 15.2 | 4.2 | 13.5 | 18.3 | 1.0 | 4.2 | 11.8 |
| NH3-N | 0.1 | 15.90 | 12.38 | 14.45 | 8.71 | 1.08 | 8.3 | 8.33 | 1.0 | 14.38 |
| NO3-N | 18.78 | 4.74 | 3.80 | 0.03 | 3.76 | 19.78 | 0.0625 | 4.53 | 14.1 | 4.11 |
| NO2-N | 0.978 | 4.798 | 0.056 | 0.009 | 0.742 | 2.240 | 0.0300 | 0.62 | 0.8 | 0.883 |
| Sulphide | NA | NA | NA | 0.031 | NA | NA | 4.8 | NA | NA | NA |
| TRC | <0.01 | 0.046 | 0.95 | <0.01 | <0.01 | 0.19 | <0.01 | <0.01 | <0.01 | 0.19 |
| | | | | | | | | | | |
| Ag - T | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.2 | <0.1 | <0.1 |
| Ag - F | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Al - T | 0.5950 | 0.1600 | 0.8750 | 1.1475 | 0.1125 | 0.1075 | 0.7775 | 0.0500 | 0.1000 | 0.0725 |
| Al - F | 0.1225 | 0.0525 | 0.2075 | 0.1275 | 0.0375 | 0.0225 | 0.2625 | 0.0650 | 0.0825 | 0.0400 |
| As - T | 0.0175 | <0.01 | <0.01 | <0.02 | 0.0100 | <0.01 | <0.01 | <0.02 | <0.01 | 0.0113 |
| As - F | 0.0138 | <0.01 | <0.01 | 0.0075 | 0.0125 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0113 |
| Be - T | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Be - F | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0050 | <0.01 | <0.01 |
| Ca - T | 33.63 | 163.00 | 33.32 | 307.75 | 50.63 | 155.61 | 69.32 | 121.45 | 164.48 | 83.89 |
| Ca - F | 33.25 | 156.25 | 32.85 | 294.75 | 49.61 | 152.18 | 60.79 | 120.08 | 166.61 | 83.13 |
| Cd - T | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cd - F | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Co - T | <0.005 | <0.005 | <0.005 | <0.005 | 0.0089 | <0.005 | <0.005 | <0.005 | 0.0038 | <0.005 |
| Co - F | <0.005 | <0.005 | <0.005 | <0.005 | 0.0118 | <0.005 | <0.005 | <0.005 | 0.0089 | <0.005 |
| Cr - T | <0.005 | 0.0335 | <0.005 | 0.0190 | 0.0040 | 0.0061 | <0.005 | <0.005 | <0.005 | 0.0175 |
| Cr - F | <0.005 | 0.0375 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.0045 |
| Cu - T | 0.0140 | 0.0350 | <0.01 | 0.0095 | 0.0065 | 0.0438 | <0.005 | 0.0105 | 0.0250 | 0.0900 |
| Cu - F | 0.0130 | 0.0350 | 0.0055 | 0.0098 | 0.0058 | 0.0270 | <0.005 | 0.0095 | 0.0193 | 0.0798 |
| Fe - T | 0.1538 | 1.7500 | 0.3288 | 0.2525 | 0.5963 | 5.2250 | 0.0988 | 0.0663 | 0.2338 | 1.2650 |
| Fe - F | 0.0475 | 0.0910 | 0.1098 | 0.1973 | 0.0545 | 0.0865 | 0.0763 | 0.0638 | 0.0215 | 0.3210 |
| Hg - T (ug/L) | 0.0250 | 0.0400 | 0.1725 | 0.0375 | 0.0260 | 0.0788 | <0.02 | 0.0250 | 0.0081 | 0.0500 |
| Hg - F (ug/L) | 0.0525 | 0.0325 | 0.1475 | 0.0288 | 0.0475 | 0.0425 | 0.0275 | 0.0625 | 0.0625 | 0.1425 |
| Mg - T | 4.93 | 9.73 | 6.08 | 10.75 | 11.75 | 10.53 | 10.63 | 20.75 | 21.50 | 13.50 |
| Mg - F | 4.85 | 9.48 | 5.99 | 10.50 | 11.25 | 10.43 | 10.50 | 20.75 | 21.50 | 13.50 |
| Mn - T | 0.1150 | 0.3775 | 0.1925 | 0.0550 | 0.0425 | 0.0650 | 0.0600 | 0.0500 | 0.0400 | 0.0900 |
| Mn - F | 0.1050 | 0.3500 | 0.1850 | 0.0525 | 0.0425 | 0.0550 | 0.0600 | 0.0500 | 0.0400 | 0.0850 |
| Mo - T | <0.005 | 0.0075 | 0.0076 | 0.0470 | <0.005 | 0.0163 | <0.005 | 0.0060 | <0.005 | 0.0073 |
| Mo - F | <0.005 | 0.0054 | 0.0055 | 0.0358 | <0.005 | 0.0140 | <0.005 | 0.0065 | <0.005 | 0.0075 |
| Ni - T | <0.01 | 0.0263 | <0.01 | <0.01 | 0.1700 | 0.0183 | 0.0125 | <0.01 | 0.0383 | 0.0445 |
| Ni - F | <0.01 | 0.0258 | <0.01 | <0.01 | 0.1650 | 0.0188 | 0.0120 | 0.0083 | 0.0390 | 0.0413 |
| Pb - T | <0.01 | 0.0163 | <0.01 | 0.0175 | <0.01 | 0.0100 | <0.01 | <0.01 | <0.01 | <0.01 |
| Pb - F | <0.01 | 0.0100 | 0.0113 | 0.0125 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Se - T | <0.01 | 0.0063 | 0.0175 | 0.0200 | 0.0100 | <0.01 | 0.0113 | 0.0125 | 0.0113 | 0.0138 |
| Se - F | <0.01 | <0.01 | <0.01 | 0.0125 | 0.0100 | <0.01 | 0.0106 | <0.02 | 0.0113 | 0.0075 |
| Sr - T | 0.1375 | 0.1900 | 0.1550 | 0.2250 | 0.1475 | 0.2250 | 0.3725 | 7.00 | 5.9125 | 0.2575 |
| Sr - F | 0.1300 | 0.1850 | 0.1550 | 0.2225 | 0.1375 | 0.2175 | 0.3775 | 7.03 | 6.0125 | 0.2575 |
| V - T | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.04 | <0.02 | <0.02 |
| V - F | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Zn - T | 0.0400 | 0.0750 | 0.0300 | 0.0475 | 0.0750 | 0.0675 | <0.01 | 0.0250 | 0.0350 | 0.0275 |
| Zn - F | 0.0475 | 0.1050 | 0.0375 | 0.0450 | 0.0725 | 0.0550 | 0.0175 | 0.0300 | 0.0475 | 0.0425 |

Note: T = Total (Unfiltered) Metal Concentration
F = Filtered Metal Concentration
NA = Not Analyzed

winter and summer samples at individual plants showed no significant difference (95 percent confidence) in the $NH_3$-N content. In some cases, lower organic loading on the plant during the winter period seems to have compensated for the lower temperatures (e.g. Huntsville). It is also possible that higher oxygen transfer capacity under winter operating conditions may have resulted in a higher degree of nitrification than possible in summer when oxygen limitations were experienced.

Effluent ammonia concentrations from both lagoons were substantially higher in winter than in summer, as shown in Table 3.7. In addition, elevated concentrations of hydrogen sulphide were measured in the Perth lagoon effluents in winter, averaging 4.8 mg/L. Hydrogen sulphide concentrations in the Lindsay lagoon effluent averaged 0.03 mg/L in winter.

A total of twelve samples from nine STPs were submitted during the winter sampling program for trace organics analyses. Results from these analyses are summarized in Table 3.8. As was the case in Table 3.6, only compounds detected at concentrations higher than the MDL are reported in Table 3.8 A total of nine organic compounds were identified in these twelve samples, including three phthalate esters and six herbicides/pesticides. Five of these compounds were also identified in samples from the summer program. Of the nine organic compounds found in winter samples, only 2,4-dichlorophenoxybutyric acid, 2,4-dichlorophenoxypropionic acid, and di-n-butylphthalate were found in more than two of the samples. In three of the effluent samples analyzed, no concentrations of target organics were higher than the MDL.

TABLE 3.8: CONCENTRATIONS OF TRACE ORGANIC COMPOUNDS DETECTED IN EFFLUENT SAMPLES, WINTER SAMPLING PROGRAM

| Compound (Concentration) | Highland Creek 23 Mar | Lindsay 30 Mar | Bracebridge 14 Dec | Midland 11 Jan | Midland 12 Jan | Walkerton 17 Jan | Walkterton 18 Jan | Wallaceburg 25 Jan | Stratford 16 Feb | Stratford 17 Feb | Perth 22 Feb | Huntsville 09 Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Di-n-butylphthalate (ug/L) | 2 | | | 2.4 | 3.0 | | | | | | | |
| Butylbenzylphthalate (ug/L) | 2 | | | | | | | | | | | |
| Bis-2-ethylhexylphthalate (ug/L) | 10 | | | | | | | 2.0 | | | | |
| 2,4-D-Propionic Acid (ng/L) | | | 125 | 100 | | | 185 | | | | | 145 |
| 2,4-Dichlorophenoxybutyric Acid (ng/L) | | | 230 | 330 | | | 270 | | 1,200* | 1,300* | | 360 |
| γ-BHC (ng/L) | | | | | | | | 90 | | | | 45 |
| β-BHC (ng/L | | | | | | | | | 40 | 90 | | |
| pp-DDT (ng/L) | | | | | | | | | | | | 55 |
| Methoxychlor (ng/L) | | | | | | | | | | | | 180 |

* Concentration cannot be confirmed due to quality control problems.

# 4.0 ANALYSIS AND INTERPRETATION OF TOXICITY TEST RESULTS

## 4.1 Effect of STP Operating and Design Conditions

### 4.1.1 Data Analysis

Probability distributions were compared to determine the effect of sample type and plant design and operation on the acute and chronic toxicity of the final effluents. In cases where the samples were dechlorinated, the toxicity results from only the dechlorinated samples were analyzed, since the toxic effects of chlorine in the samples would mask the effects that sample type or plant operation might have on the results. For the purposes of this analysis, all samples which had an LC50 greater than 100 (acute tests) or a chronic value greater than 100 (chronic tests) were assigned a toxicity of 100. In the case of the fathead minnow chronic toxicity data where some samples had a reported chronic value of less than 10, these samples were assigned a value of 5.

To compare the effect of different conditions on effluent toxicity, a non-parametric statistical procedure as described by Helsel (1987) was used. Unlike standard parametric statistical procedures such as t-tests to compare sample means, the non-parametric procedure used in this analysis is "robust" to non-normally distributed data sets such as water quality data. For the purposes of presentation, the toxicity results have been shown as normal distributions on normal probability graph paper; however, the actual distribution of the data does not affect the validity of the statistical procedure used.

It must be recognized in interpreting the test results that the data base is limited to ten Ontario STPs (two lagoons, two tertiary plants and six secondary plants). Furthermore, because of the nature of the full-scale sampling program, the effect of one operating or design parameter on effluent toxicity could not be isolated from the effects of other parameters. Therefore, the extrapolation of any trends from these data to all Ontario STPs must be done with caution. Correlations between toxicity and STP design need to be confirmed by more extensive sampling and by controlled experimentation in which the effects of each parameter can be isolated and evaluated independently.

### 4.1.2 Sampling Procedures

As noted in Section 2.2, grab samples were collected at five of the ten STPs included in the test program to determine the effect of sampling procedure on the measured effluent toxicity. Only acute toxicity tests (rainbow trout and *Daphnia magna*) were performed on the grab samples. The plants at which grab samples were collected were identified in Table 2.4, along with the schedule for grab sample collection at each plant.

Figure 4.1 presents the probability distributions of LC50 data for rainbow trout lethality tests conducted on grab samples and composite samples collected at the same plants. The total number of composite samples included in the distribution is 40 (five STPs each sampled four times in summer and winter). The total number of grab samples included is 44 from the same five STPs (22 samples in summer and 22 samples in winter).

There was no statistically significant difference (95 percent confidence level) between the distributions of rainbow trout LC50 data for composite samples and similar data for grab samples collected at the same plants. In the case of composite samples, 47.5 percent (19 samples) of the 40 samples collected at these five plants had LC50 values greater than 100 percent. For grab samples collected at the same plants, 52.2 percent (23 samples) exhibited LC50 values greater than 100.

Figure 4.2 presents the probability distribution of LC50 data for *Daphnia magna* lethality tests on grab samples and composite samples collected at the same plants. The majority of grab and composite samples exhibited no acute lethality to the test species. In the case of composite samples, 90 percent (36 samples) of the samples collected showed LC50 values greater than 100. For the grab samples collected at the same plants, 93.2 percent (41 samples) had LC50 values greater than 100. Due to the low acute lethality of both composite and grab samples to *Daphnia magna*, no statistically supportable conclusions can be drawn regarding the relative toxicity of grab and composite samples. However, the data in Figure 4.2 suggest that the type of sample analyzed had no effect on the results.

Correlation analyses were also performed on trout and daphnid test data by pairing each grab sample test result with the result of the test performed on the composite sample collected the same day. Therefore, for days during which more than one grab sample was

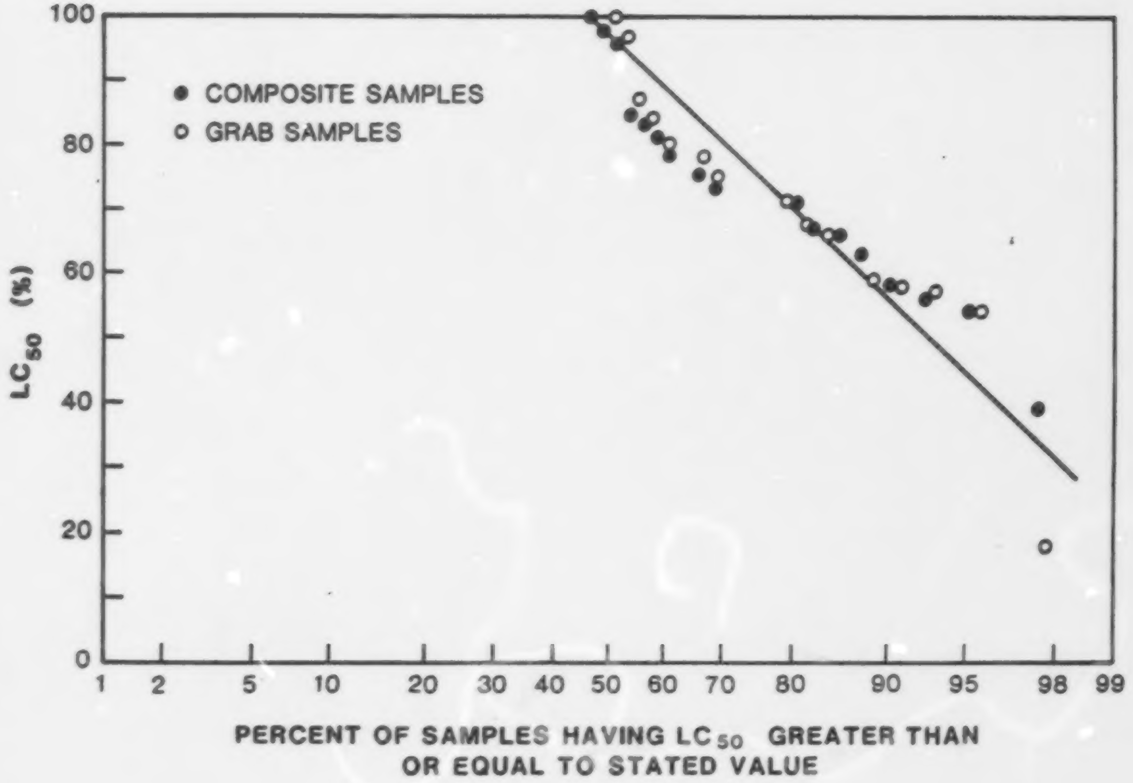


FIGURE 4.1: EFFECT OF SAMPLE TYPE ON RAINBOW TROUT LETHALITY

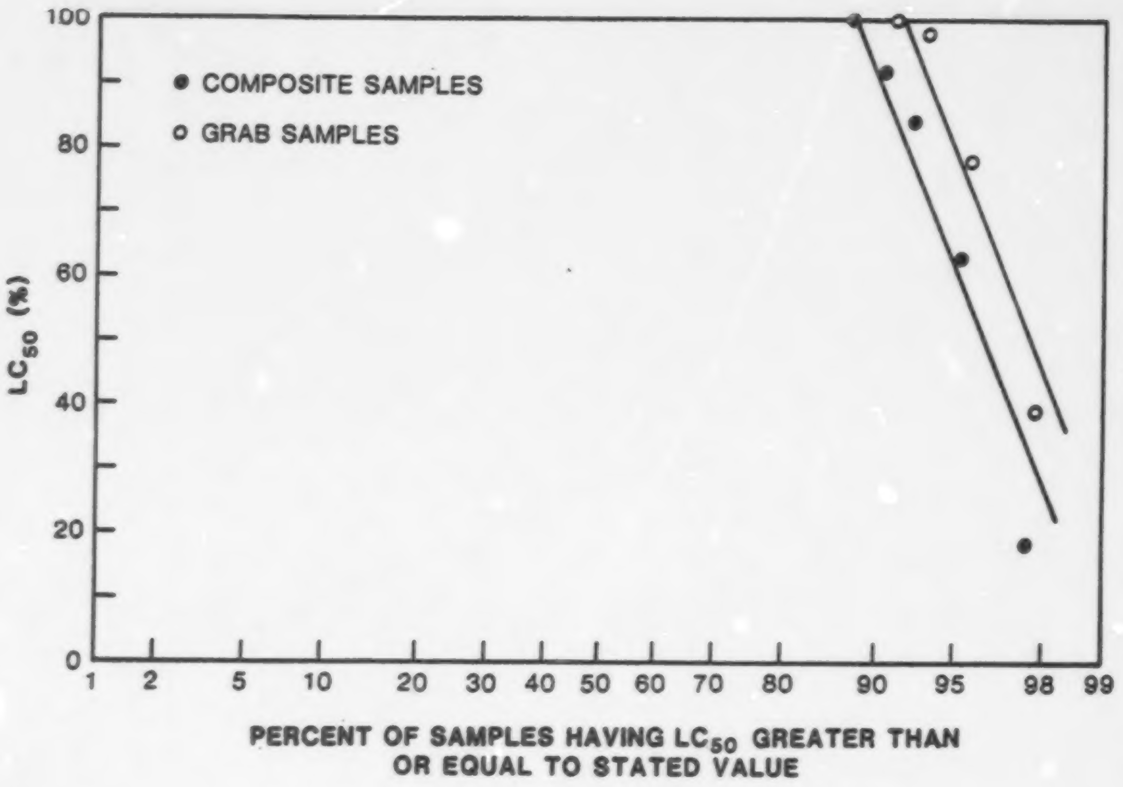


FIGURE 4.2: EFFECT OF SAMPLE TYPE ON DAPHNIA MAGNA LETHALITY

collected, this entailed repeatedly pairing the single composite sample result for that day with each grab sample result. Grab and composite sample results (including all untreated and dechlorinated samples for which both a grab and composite sample result were available, lethal and non-lethal results) were significantly correlated (95% confidence level) for both rainbow trout ($r^2$ = 0.51) and D. magna tests ($r^2$ = 0.27). Furthermore, both grab and composite sample test results agreed in 86% (rainbow trout) and 82% (D. magna) of cases in assessing whether or not the effluent was acutely lethal or non-lethal (Table 4.1). In less than 6% (rainbow trout) and 4% (D. magna) of all comparisons were composite samples lethal when grab samples were non-lethal, whereas the reverse occurred in 9% and 15% of comparisons. This suggests that, of the two methods, grab sampling would be the more conservative approach with respect to detecting potentially lethal conditions.

By comparison, analysis based only on lethal sample data resulted in a poor correlation between grab and composite test results ($r^2$ = 0.04, and 0.06 for rainbow trout (n = 30 pairs) and D. magna (n = 6 pairs), respectively). This indicates that the LC50 of a grab sample will not necessarily be similar to the LC50 of a composite sample collected on the same day. The mean difference between LC50s for corresponding grab and composite samples was not significantly different from zero (95% confidence level), however, indicating that neither sample collection method resulted in LC50s which were consistently lower or higher than the other.

Current monitoring programs in Ontario focus primarily on the assessment of effluent lethality versus non-lethality, rather than degree of lethality. As discussed above, toxicity tests conducted on grab samples usually resulted in the same conclusion as composite samples as to whether a sample was acutely lethal and, when results differed, tests performed on the grab sample were more frequently lethal than the composite. Therefore, STP effluent monitoring could be satisfactorily accomplished using the grab sampling technique with less effort and cost than would be associated with composite sampling.

Although the statistical analysis showed no significant differences between the acute toxicity of grab and composite samples, only data generated from composite samples were used in the analysis of the effect of plant design and operation on effluent toxicity. This was done, in part, to ensure that no bias was introduced as a result of too

## TABLE 4.1: COMPARISON OF GRAB VS. COMPOSITE SAMPLE TEST RESULTS FOR ESTIMATION OF ACUTE EFFLUENT LETHALITY

| | Agree[a] | Grab Lethal, Composite Non-Lethal | Composite Lethal, Grab Non-Lethal |
|---|---|---|---|
| **Rainbow Trout** | | | |
| Summer | 81% | 15% | 3.8% |
| Winter | 96% | 3.8% | - |
| All | 89% | 9.3% | 1.9% |
| **Daphnia magna** | | | |
| Summer | 75% | 18% | 11% |
| Winter | 85% | 15% | - |
| All | 78% | 16% | 5.5% |

[a] Both composite and grab results indicated sample was either acutely lethal or non-lethal; a sample was considered non-lethal if 50% or fewer organisms died.

much weighting of operational data associated with the STPs from which grab samples were taken relative to those where none were collected. Also, composite samples more accurately reflect the longer time frame associated with such operational parameters as SRT and loading on effluent quality. Since the results of Daphnia magna lethality tests did not show sufficient toxicity to support rigorous statistical analysis, only the results of rainbow trout lethality tests were used in the data analysis.

### 4.1.3 Seasonal Effects

#### 4.1.3.1 Acute Toxicity

Acute toxicity to rainbow trout of composite samples of effluents collected under cold weather (winter) conditions was compared with those collected under warm weather (summer) conditions (Figure 4.3). A comparison of these frequency distributions shows that the winter samples were significantly more toxic than the summer samples (95 percent confidence) based on the rainbow trout lethality test (see also Section 3.1.1.1). There were considerably more samples during the summer (30 of 39 samples) which exhibited LC50s greater than 100% than during the winter (18 of 40 samples) although this trend was attributable to samples from only four of the ten STPs (Highland Creek, Lindsay, Perth, Wallaceburg). It is reiterated that the data presented in Figure 4.3 are for dechlorinated samples, where dechlorination was performed, to eliminate chlorine-induced acute toxicity. Therefore, the seasonal effect observed is independent of the potential effect of chlorine. The relationship between toxicity and other specific effluent contaminants is discussed in Section 4.4.

All acute toxicity in samples from the two lagoons included in the test program was associated with samples collected in the winter period. All summer samples were non-lethal (LC50 greater than 100% effluent); whereas, all winter samples exhibited LC50s of less than 100% for rainbow trout.

As noted in Section 4.1.2, Daphnia magna toxicity data did not support a statistical analysis due to the low number of acutely lethal effluents.

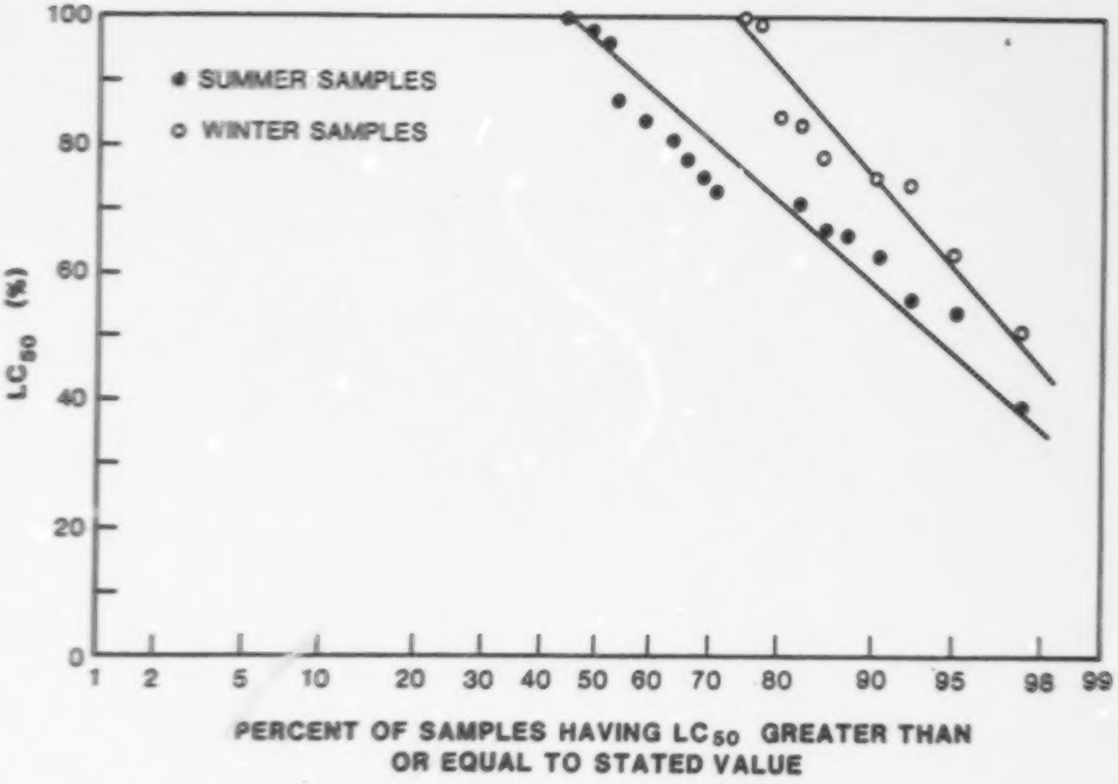


FIGURE 4.3: EFFECT OF SEASONAL CONDITIONS ON RAINBOW TROUT LETHALITY

#### 4.1.3.2 Chronic Toxicity

Summer samples were significantly less toxic (95% confidence level) to C. dubia in chronic tests than winter samples (Figure 4.4). There was a marked difference between the number of samples which showed no chronic toxicity in summer (25 samples out of 40) compared to winter (10 samples out of 40). In the case of the fathead minnow test data, however, there was no significant difference between the chronic toxicity which could be related to seasonal effects (Figure 4.5). Similar numbers of samples exhibited no toxic effect in both seasons (14 samples in summer compared to 11 samples in winter).

The pattern of winter toxicity in lagoon samples identified in the rainbow trout lethality data was also apparent in the chronic toxicity data. In the C. dubia test data, all of the eight summer samples from the lagoons were non-toxic compared to only one of the eight winter samples. In the fathead minnow test data, three of the eight summer samples showed no chronic effect while all of the eight winter samples exhibited chronic toxicity (i.e. chronic values less than 100%).

### 4.1.4 Effect of Plant Type

#### 4.1.4.1 Acute Toxicity

Figure 4.6 compares the toxicity to rainbow trout of effluents from the six secondary treatment plants, two lagoons and two tertiary plants which incorporated final effluent filtration. Although the data suggest a trend toward lower toxicity in effluents from the secondary plants, the effect of plant type on the effluent LC50 was not significant at the 95 percent confidence level. However, there was a greater number of non-lethal samples (LC50 greater than 100) collected from secondary plants than from the other two types of plants. Thirty-two of the 47 secondary effluent samples (68%) tested had an LC50 greater than 100, compared to 8 of 16 (50%) tertiary plant effluents and 8 of 16 (50%) lagoon effluents.

It should again be noted that the data base is small (only two lagoons and two tertiary plants). Acute Daphnia magna toxicity data did not support detailed statistical analysis.

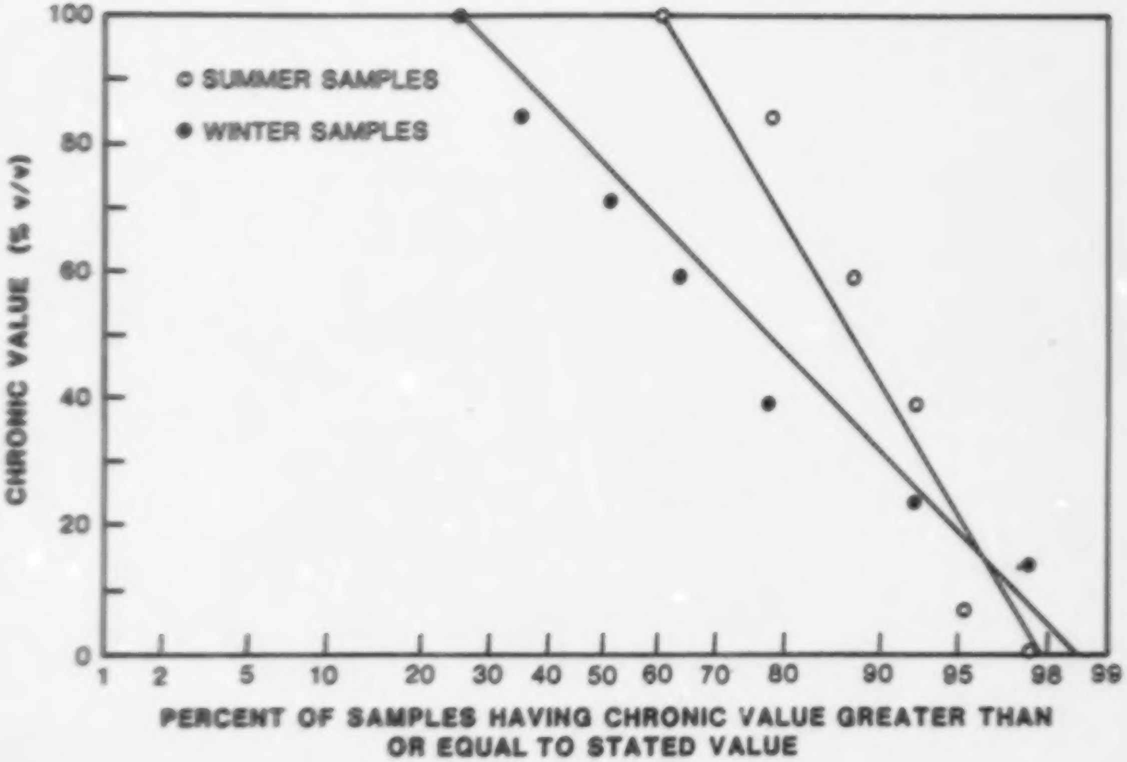


FIGURE 4.4: EFFECT OF SEASONAL CONDITIONS ON CERIODAPHNIA TOXICITY

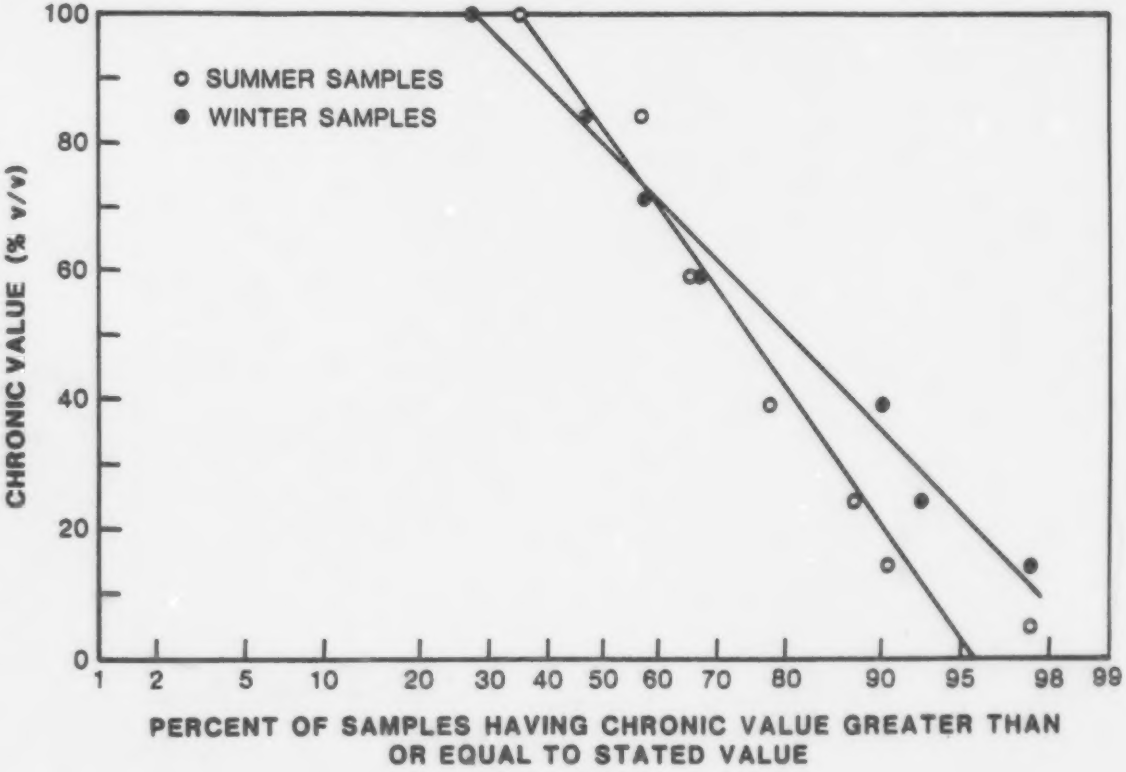


FIGURE 4.5: EFFECT OF SEASONAL CONDITIONS ON FATHEAD MINNOW TOXICITY

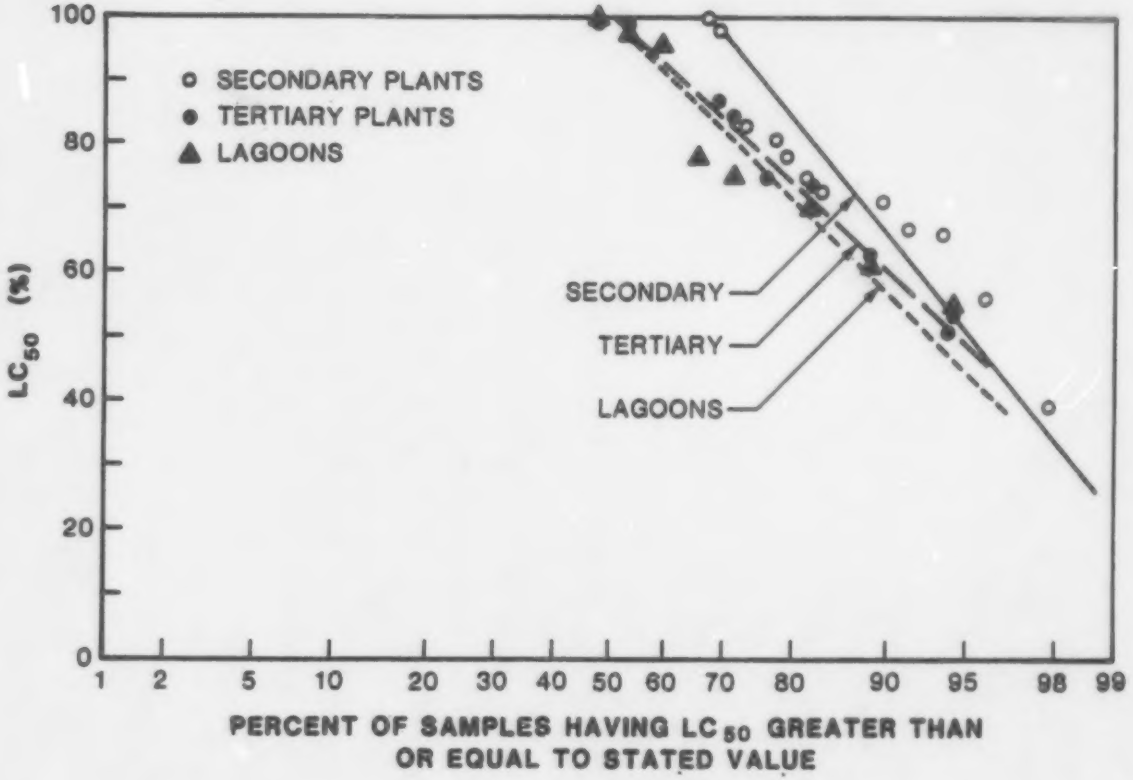


FIGURE 4.6: EFFECT OF PLANT TYPE ON RAINBOW TROUT TOXICITY

#### 4.1.4.2 Chronic Toxicity

Chronic test data followed a trend similar to that apparent from acute toxicity test results. Effluents from tertiary plants appear to be somewhat less toxic to C. dubia than those from secondary plants or lagoons (Figure 4.7). Similarly, based on the fathead minnow test data, it appears that lagoon effluents are somewhat more toxic than effluents (56%) from either secondary or tertiary plants (Figure 4.8). However, based on the non-parametric comparison of ranks, these data do not support the conclusion that the toxicity of the effluents are different at the 95 percent confidence level.

The percentage of samples which exhibited no effect on C. dubia reproduction were comparable for all plant types. Nine of 16 lagoon effluents (56%) were non-toxic compared to 9 of 16 (56%) tertiary plant effluents and 20 of 48 (42%) secondary plant effluents. More secondary and tertiary effluents exhibited no effect on fathead minnow growth (5 of 16 tertiary effluents and 17 of 48 secondary effluents) compared to lagoon effluents (3 of 16 samples).

### 4.1.5 Effect of Industrial Wastewater Contribution

Since the industrial load contribution to each of the ten STPs could not be precisely quantified based on available data, a subjective ranking of "high", "medium" or "low" was applied to describe the approximate contribution to each plant from industrial sources. The subjective rankings, which are summarized in Table 4.2, were based on discussions with the plant operating authority and information available from other sources regarding the type of industry tributary to the plant.

Detailed discussions regarding the types of industries tributary to each plant and the flow contributers are included in the STP descriptions in Appendix A. Where a quantitative estimate of industrial flow was available, a "low" ranking was applied if the flow contribution was less than 10 percent of the total STP flow. A "medium" ranking was applied for flow contributions in the 10 to 19 percent range. A "high" ranking signified an industrial contribution higher than 20 percent. Where no quantitative estimate of industrial flow was available, STPs were placed in categories based on the number and types of industries known to discharge to the sanitary sewer and the operating authority's best qualitative estimate of flow from industrial sources. This ranking system did not

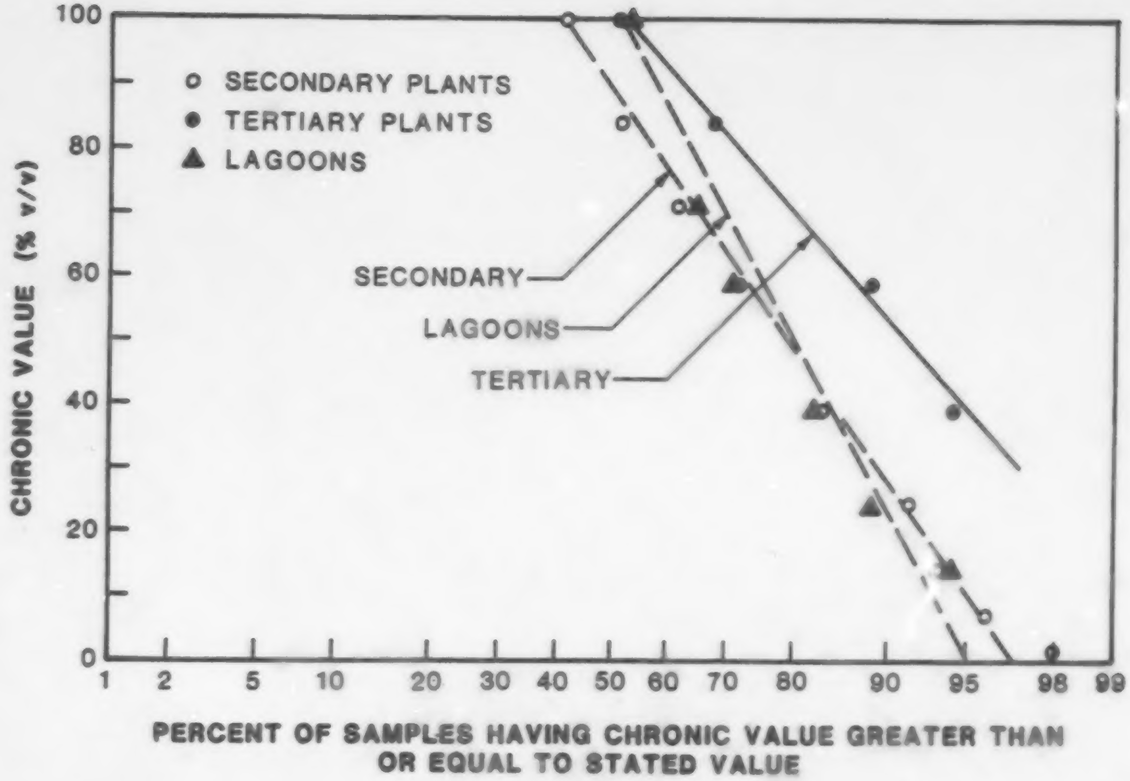


FIGURE 4.7: EFFECT OF PLANT TYPE ON CERIODAPHNIA TOXICITY

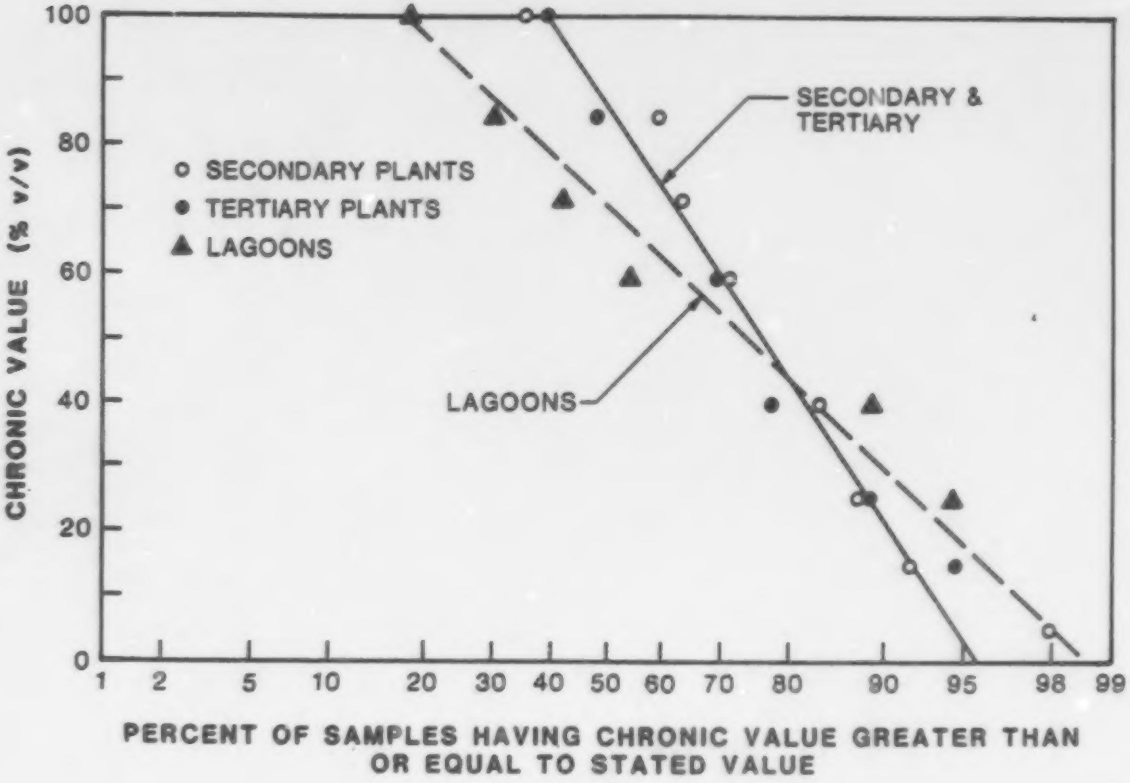


FIGURE 4.8: EFFECT OF PLANT TYPE ON FATHEAD MINNOW TOXICITY

## TABLE 4.2: CATEGORIZATION OF STPs BY INDUSTRIAL CONTRIBUTION

| Plant | Approximate Percent Industrial Flow | Industrial Category* |
|---|---|---|
| Bracebridge | N.A. | Low |
| Highland Creek | 20 | High |
| Huntsville | N.A. | Low |
| Lindsay | 25 | High |
| Midland | 40 | High |
| North Toronto | 10 | Medium |
| Perth | N.A. | Low |
| Stratford | N.A. | Medium |
| Walkerton | 30 | High |
| Wallaceburg | 40 | High |

N.A. = not available.

* See text.

consider the degree of industrial wastewater pretreatment enforced in the municipality. On the basis of these rankings, an analysis of the impact of industrial load on the acute and chronic toxicity of the plant effluents was undertaken. It should be noted that the number of STPs in each category ranged from a minimum of two to a maximum of five; results of data interpretation should be treated with caution due to the small size of the database.

#### 4.1.5.1 Acute Toxicity

A plot of the effect of industrial loading on rainbow trout acute toxicity (Figure 4.9) suggests that effluents from plants with a low industrial load are less actuely toxic to rainbow trout than that of STPs receiving medium or high industrial loads. Also, STPs classified as having "high" and "medium" industrial loadings exhibited similar percentages of non-lethal effluent samples (56% in both cases), whereas STPs classified as having a "low" industrial contribution had a substantially higher percentage of non-lethal effluent samples (71%). A statistical analysis of the data, however, showed no differences between the distributions of toxicity data for plants with high, medium or low industrial contributions (95% confidence level). Hence, it cannot be concluded from this data base that industrial load has an effect on the acute toxicity of the STP effluent to rainbow trout.

#### 4.1.5.2 Chronic Toxicity

The results of the C. dubia test show a trend toward greater chronic effect as the industrial load on the plant increases from low to high (Figure 4.10). The difference between the chronic toxicity of effluents from STPs classified as having a "high" industrial loading and those having a "low" loading was significant at the 95% confidence level. The differences between the "low" and "medium" and between the "medium" and "high" categorized plants were not significant at the same level of confidence. The STPs classified as having a "low" industrial load had a substantially higher percentage of samples which exhibited no chronic effect on C. dubia (67%) compared to the STPs classified as having a "medium" loading (21%) or a "high" loading (35%).

The chronic toxicity data from the fathead minnow tests did not indicate any statistically significant differences due to the industrial load to the plant (Figure 4.11).

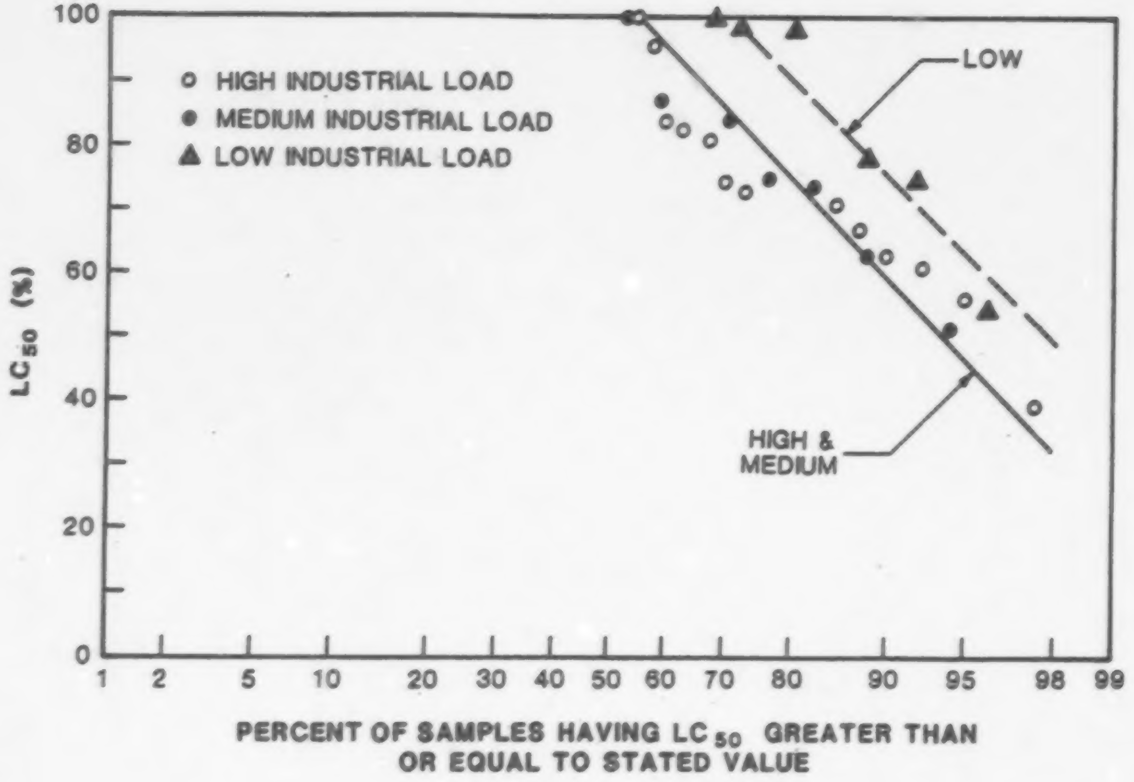


FIGURE 4.9 : EFFECT OF INDUSTRIAL LOAD ON RAINBOW TROUT TOXICITY

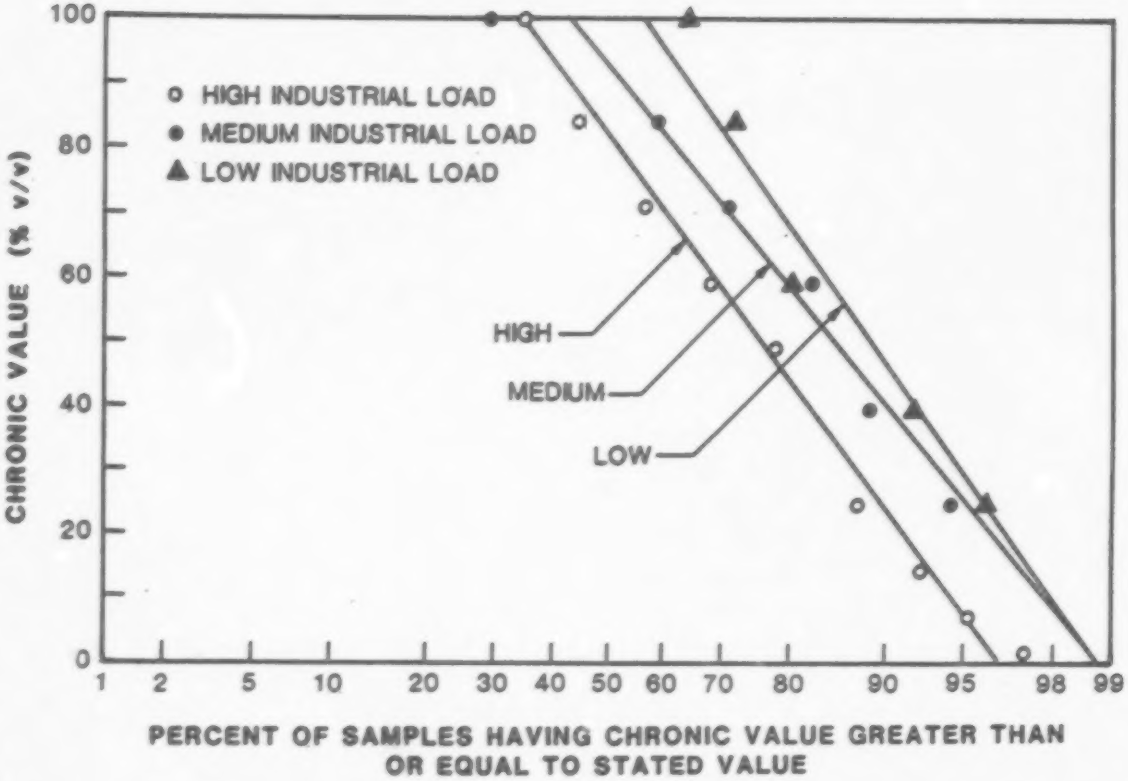


FIGURE 4.10: EFFECT OF INDUSTRIAL LOAD ON CERIODAPHNIA TOXICITY

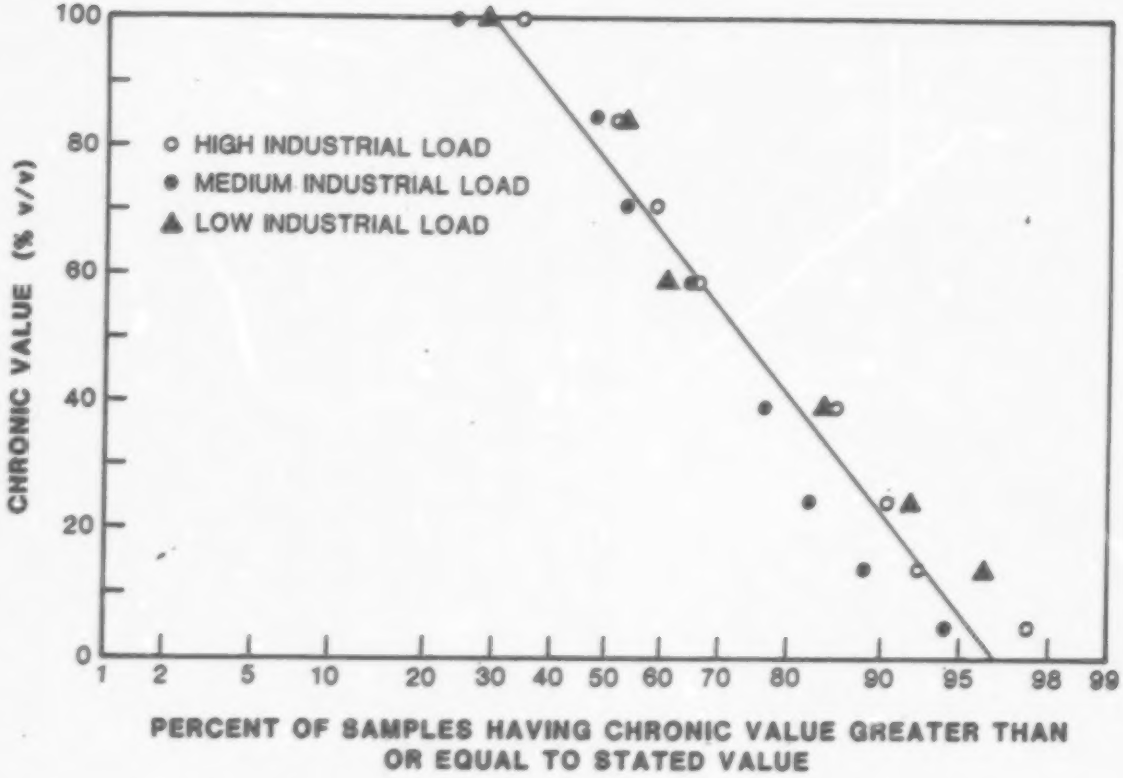


FIGURE 4.11 : EFFECT OF INDUSTRIAL LOAD ON FATHEAD MINNOW TOXICITY

All categories of plants showed a similar percentage of samples which exhibited no chronic effect - 35 percent of samples from plants classified as having a "high" industrial load contribution, 25 percent of samples from plants classified as "medium" and 29 percent of samples from plants classified as "low".

### 4.1.6 Effect of Operational Conditions

The effect of plant hydraulic loading on the acute and chronic toxicity of the effluents from the STPs included in the test program was assessed by comparing the toxicity of effluents from plants operating at less than 80 percent of design hydraulic loading with that of plants operating at more than 80 percent of design hydraulic loading. This comparison was based on all ten of the STPs regardless of plant type. As noted previously, the Daphnia magna toxicity data did not support an intensive data analysis due to the low percentage of lethal samples.

The effects of organic loading and aeration basin hydraulic retention time (HRT) were evaluated for secondary treatment plants only. Although the data did not show a statistically significant difference in the toxicity of secondary and tertiary STP effluents, the data analysis was limited to secondary plants to eliminate any possibility of plant type affecting the data interpretation. Lagoons were excluded since the operating variables considered were not relevant to lagoon operation. Organic loading effects were analyzed based on both F/M ratios (g $BOD_5$ applied to the aeration tank per g MLVSS/d) and solids retention time (SRT, days), since in many of the plants SRTs could not be calculated from the plant records of sludge wastage and had to be estimated based on the food to microorganism (F/M) ratio. A subjective division between plants operating at "high" and "low" loading conditions was made. Plants operating at "low" loading were defined as those in which the F/M ratio was less than 0.18 or the SRT was more than 10 days. A similar division of plants was made based on aeration basin HRT. In this case, plants were divided into two categories - those operating at an HRT greater than 6 hours and those operating at an HRT less than 6 hours. The quantitative limits placed on F/M, SRT and HRT were based on the upper or lower ranges identified in the MOE Design Guidelines for Sewage Treatment Plants (MOE, 1984b).

Table 4.3 indicates which plants were classified in which of the operational categories in each sampling period. The classification was based on the operating conditions at the

TABLE 4.3: CLASSIFICATION OF STPs BY OPERATING CONDITION

|  | Plants Included |  |
|---|---|---|
|  | Summer | Winter |
| SRT greater than 10 days | Highland Creek<br>Walkerton | Highland Creek<br>Walkerton<br>Midland |
| SRT less than 10 days | Huntsville<br>North Toronto<br>Wallaceburg<br>Midland | Huntsville<br>North Toronto<br>Wallaceburg |
| F/M less than 0.18 | Highland Creek<br>North Toronto<br>Walkerton | Highland Creek<br>Midland |
| F/M greater than 0.18 | Huntsville<br>Wallaceburg<br>Midland | Huntsville<br>Wallaceburg<br>North Toronto<br>Walkerton |
| HRT greater than 6 hours | Highland Creek<br>North Toronto<br>Walkerton<br>Huntsville | Highland Creek<br>North Toronto<br>Walkerton |
| HRT less than 6 hours | Midland<br>Wallaceburg | Midland<br>Wallaceburg<br>Huntsville |
| Hydraulic Load less than 80% Design | Bracebridge<br>Lindsay<br>Perth<br>Stratford<br>Walkerton | Bracebridge<br>Lindsay<br>Highland Creek<br>Midland<br>North Toronto |
| Hydraulic Load greater than 80% Design | Huntsville<br>Wallaceburg<br>Highland Creek<br>Midland<br>North Toronto | Huntsville<br>Wallaceburg<br>Perth<br>Stratford<br>Walkerton |

plant during the two weeks prior to the sampling. Thus, a plant could be classified in different categories during the summer sampling period than during the winter sampling period.

In the interpretation of these data, it must be recognized that the data base is small and interpolation of trends in these data to all Ontario STPs may not be valid. It should also be recognized that many parameters other than those analyzed were also varying at these STPs and might also influence the toxicity of the plant effluent.

#### 4.1.6.1 Acute Toxicity

There was no significant effect (95 percent confidence) of hydraulic loading on the acute toxicity of effluents from all ten STPs based on the separation of plants into categories of less than 80 percent of design hydraulic load and more than 80 percent of design hydraulic load (Figure 4.12).

The effects of organic loading (F/M and SRT) and aeration basin HRT on the acute toxicity of secondary treatment plant effluents are shown in Figures 4.13, 4.14 and 4.15. Organic loading, measured as either F/M or SRT, had no significant effect on the effluent toxicity (95 percent confidence) at the six secondary STPs included in this sampling program. The statistical analysis of the effect of HRT on acute toxicity of the secondary STP effluents (Figure 4.15) shows a significant difference in the results between plants with aeration basin HRTs greater than 6 hours compared to those with shorter, aeration basin HRTs. Longer HRT resulted in fewer acutely lethal samples to trout. It should be noted that this analysis is based on a total of six secondary STPs only, and influences other than aeration basin HRT may be contributing to the observed effect.

#### 4.1.6.2 Chronic Toxicity

Based on the loading categories selected, hydraulic load had no significant effect (95 percent confidence) on the chronic toxicity of the effluent samples to either C. dubia (Figure 4.16) or fathead minnows (Figure 4.17) at the ten STPs.

The effect of secondary treatment plant loading conditions (F/M, SRT and aeration tank HRT) on the chronic toxicity of the effluent to C. dubia is shown in Figures 4.18, 4.19

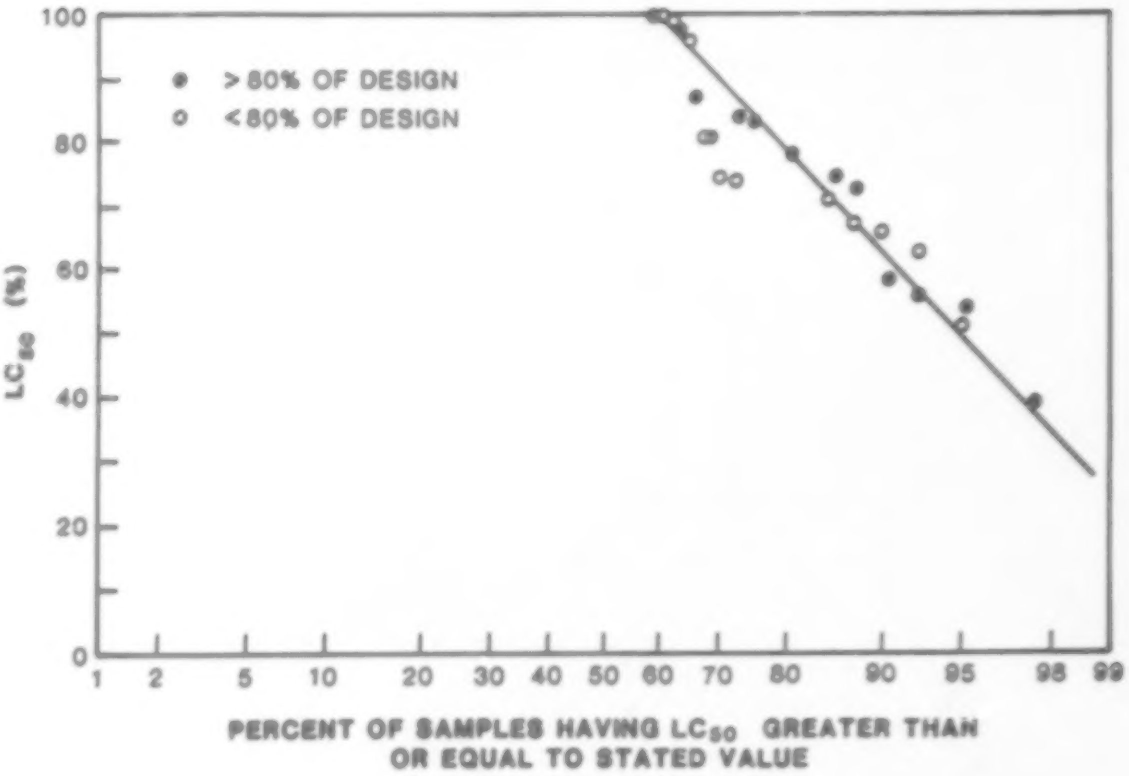


FIGURE 4.12: EFFECT OF HYDRAULIC LOADING ON RAINBOW TROUT TOXICITY

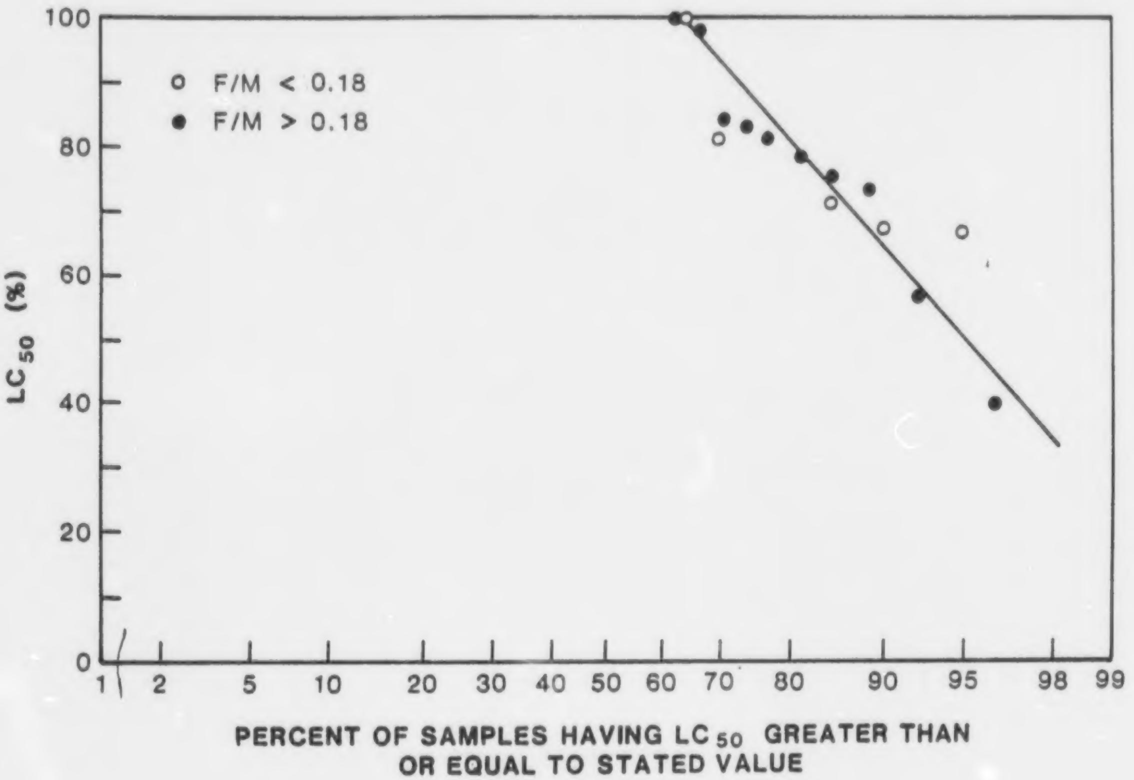


FIGURE 4.13: EFFECT OF F/M LOADING ON RAINBOW TROUT TOXICITY

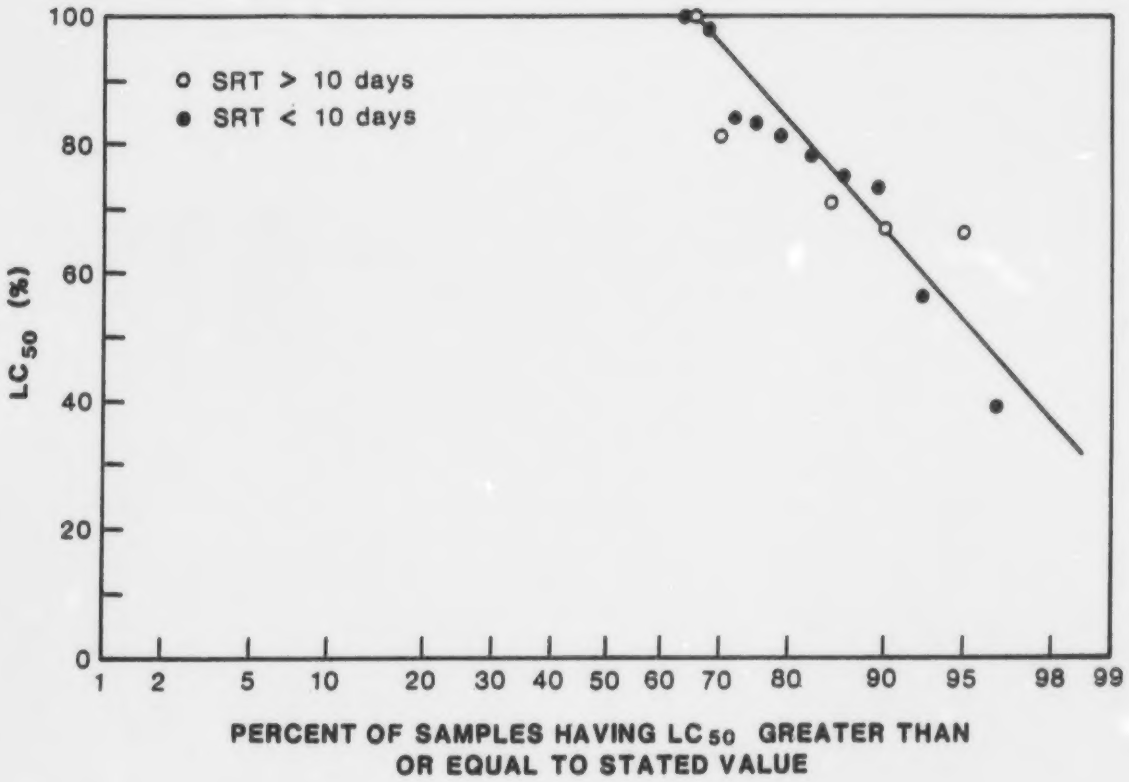


FIGURE 4.14: EFFECT OF SRT ON RAINBOW TROUT TOXICITY

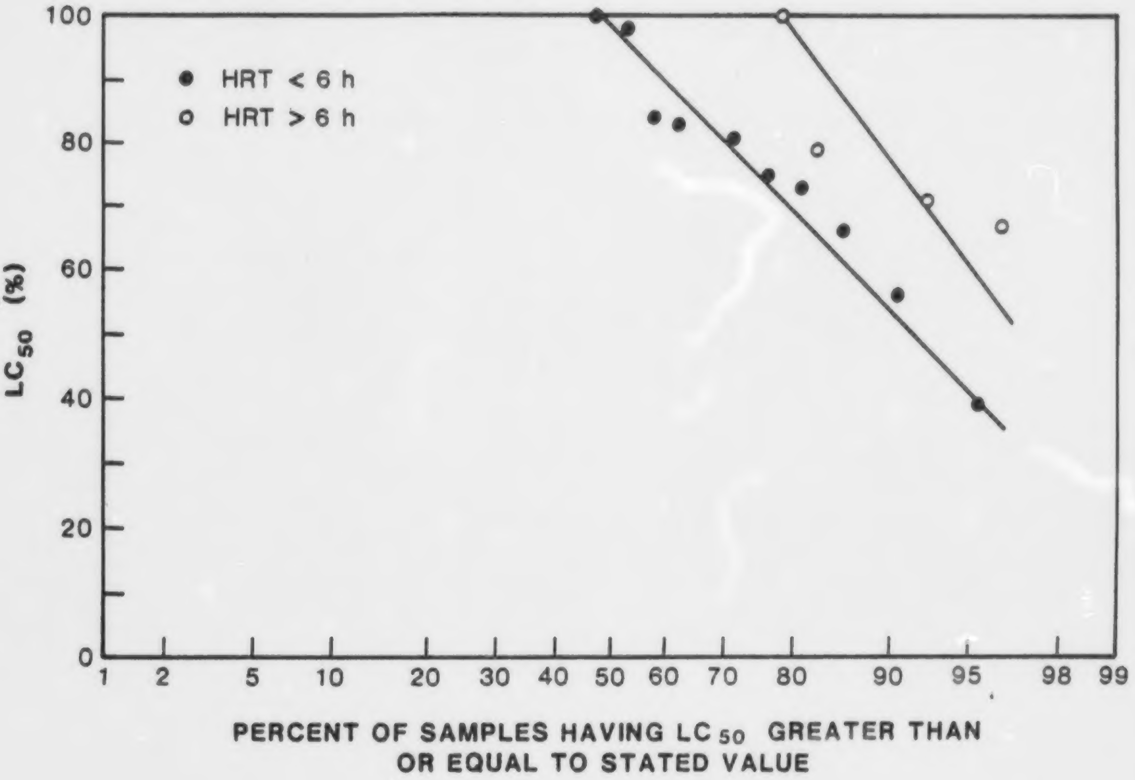


FIGURE 4.15: EFFECT OF AERATION TANK HRT ON RAINBOW TROUT TOXICITY

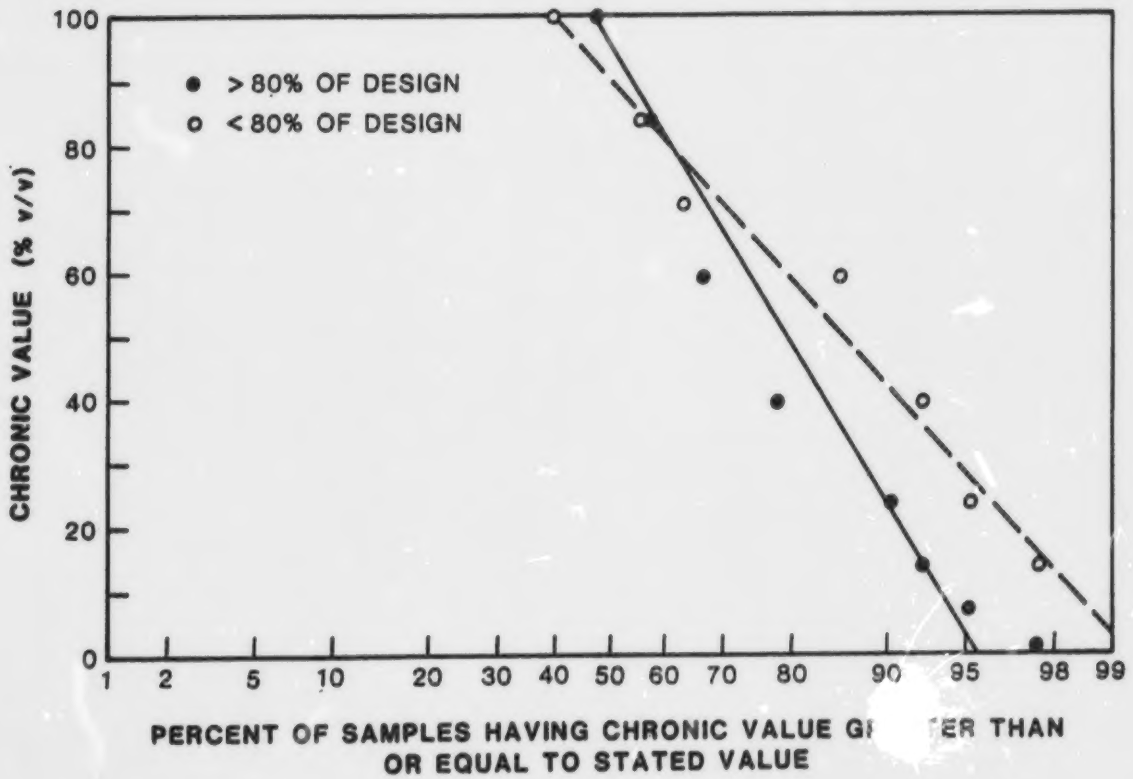


FIGURE 4.16: EFFECT OF HYDRAULIC LOADING ON CERIODAPHNIA TOXICITY

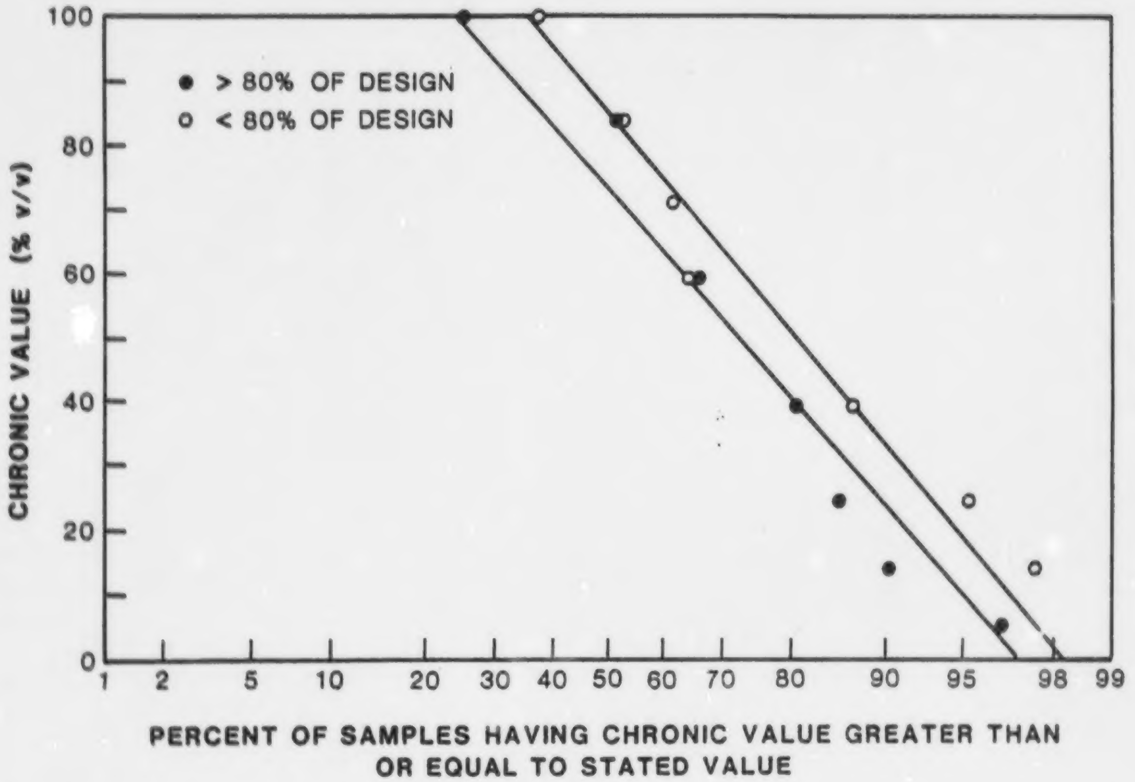


FIGURE 4.17: EFFECT OF HYDRAULIC LOADING ON FATHEAD MINNOW TOXICITY

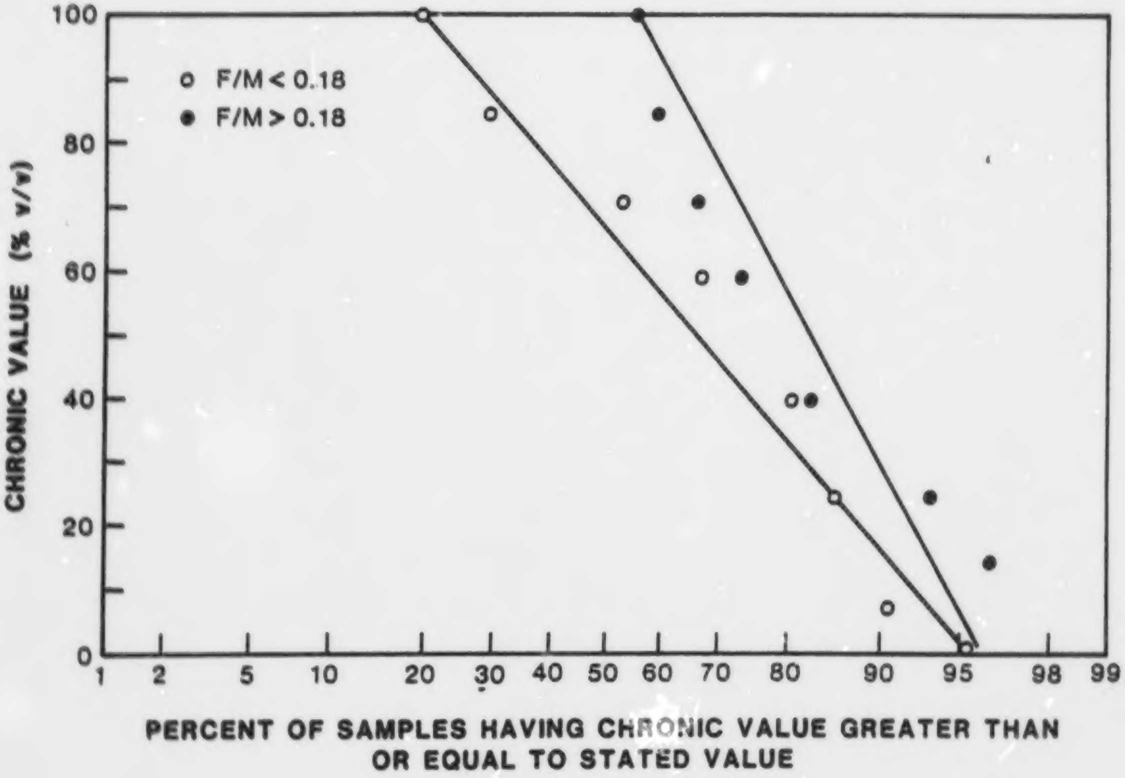


FIGURE 4.18: EFFECT OF F/M LOADING ON CERIODAPHNIA TOXICITY

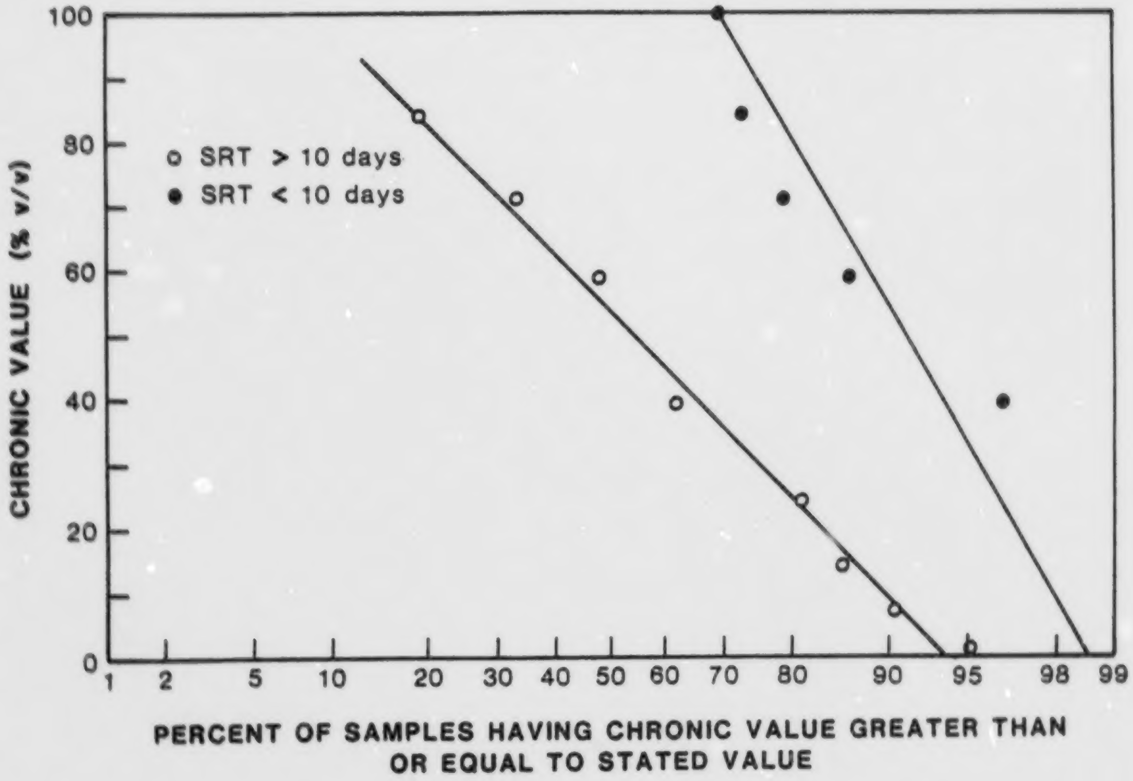


FIGURE 4.19 : EFFECT OF SRT ON CERIODAPHNIA TOXICITY

and 4.20. In all three cases, the data suggest trends which are the reverse of those which would be expected. A greater degree of chronic toxicity is evident at lower organic loadings (lower F/M or higher SRT) and lower hydraulic loadings (higher HRTs). The effect of F/M is not statistically significant (95 percent confidence); however, the effects of SRT and HRT are significant. It is also noteworthy that none of the 20 samples collected from secondary plants operating at SRTs greater than 10 days was non-toxic. As noted previously, the inter-relationship between variables (F/M, HRT, SRT) in this study, confounds interpretation of any single variable effect. Therefore, no definitive relationship between SRT or HRT and effluent chronic toxicity should be concluded from these data.

The effect of these same loading conditions on effluent chronic toxicity to fathead minnows is illustrated in Figures 4.21, 4.22 and 4.23. The same trend in the data is apparent as noted in the C. dubia data; that is, toxicity increases as organic load decreases. In this case, neither the F/M effect nor the HRT effect is statistically significant; however, these data suggest that chronic toxicity is greater from plants operated at higher SRTs (95 percent confidence level).

## 4.2 Changes in Effluent Chemistry

### 4.2.1 During Sample Transport

Ammonia

Field and laboratory personnel periodically conducted QC checks to verify that the Hach kits used in the field and at the toxicity laboratory gave similar readings (Appendix C). Despite this effort, some degree of discrepancy between field and lab analysis was observed and was attributed to the reliability of the method and differences between instruments, analyst performance and reagents used. For this reason, a difference of greater than ± 10% in laboratory-relative to field-measured ammonia concentrations was judged to be necessary to indicate a real change in sample ammonia.

Total ammonia concentrations measured in the field versus the lab differed by more than a factor of ± 10% in 76% of all samples (Figure 4.24). Total ammonia levels measured in the laboratory ranged from a 61% decrease to 392% of field levels. Extreme values were

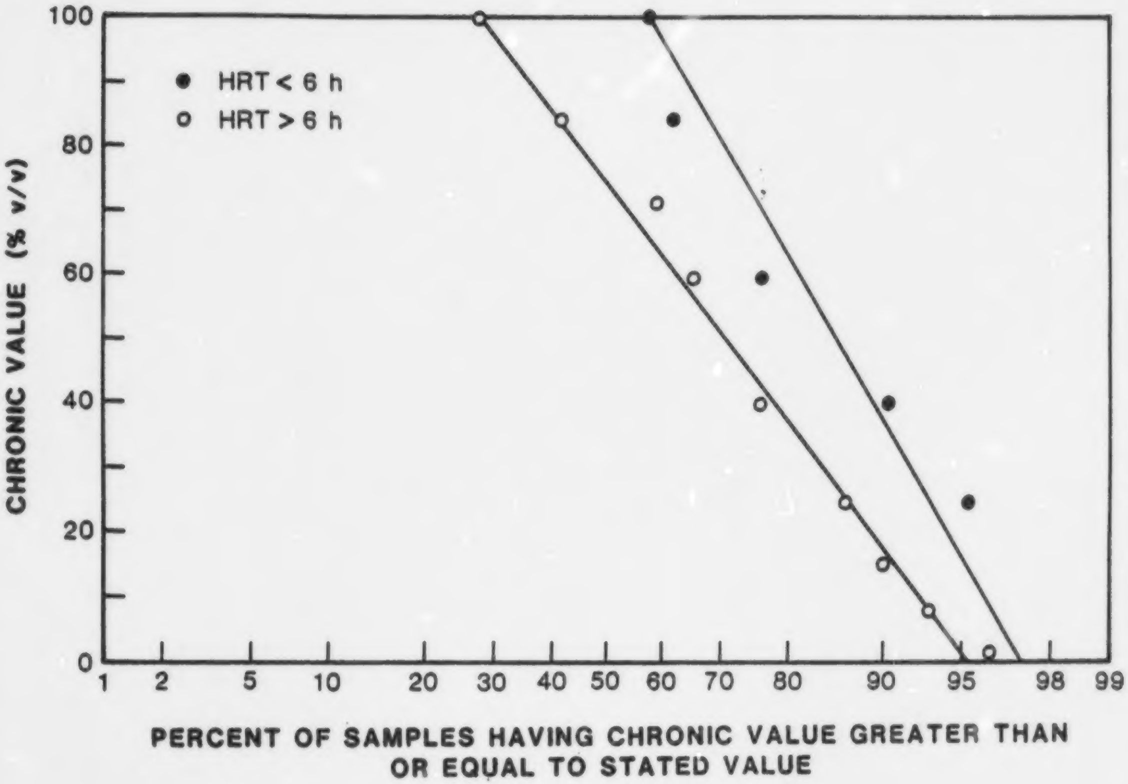


FIGURE 4.20: EFFECT OF AERATION TANK HRT ON CERIODAPHNIA TOXICITY

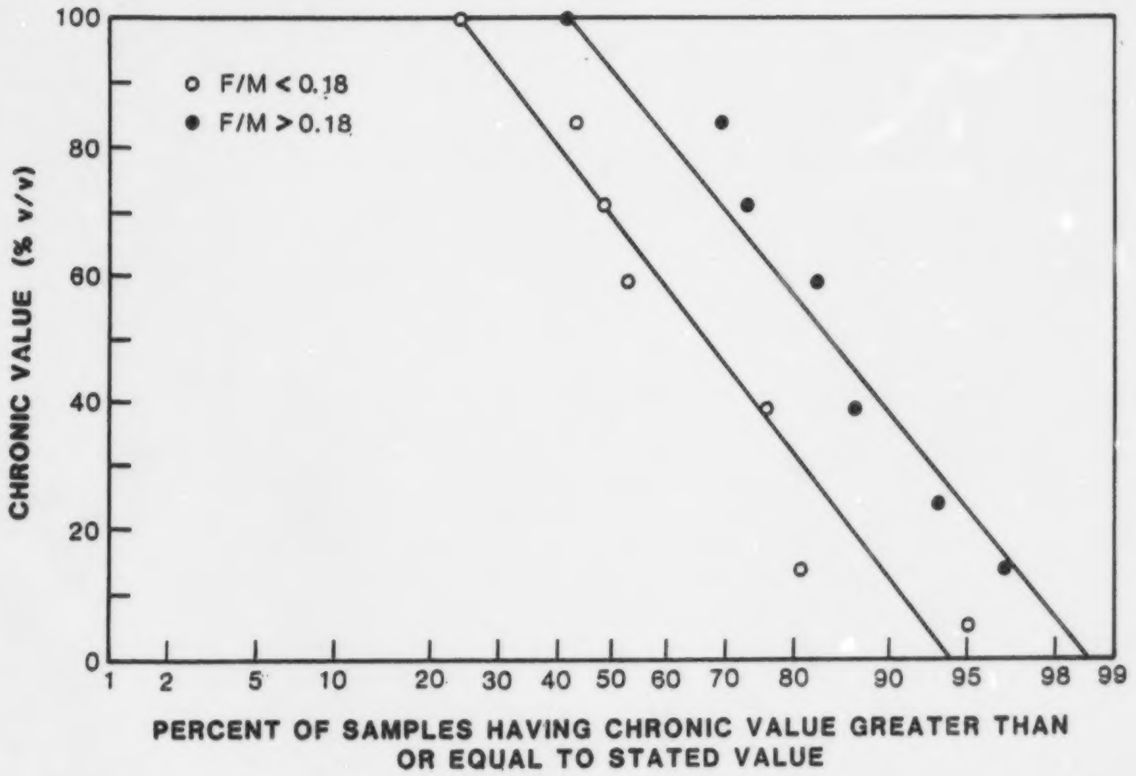


FIGURE 4.21 : EFFECT OF F/M LOADING ON FATHEAD MINNOW TOXICITY

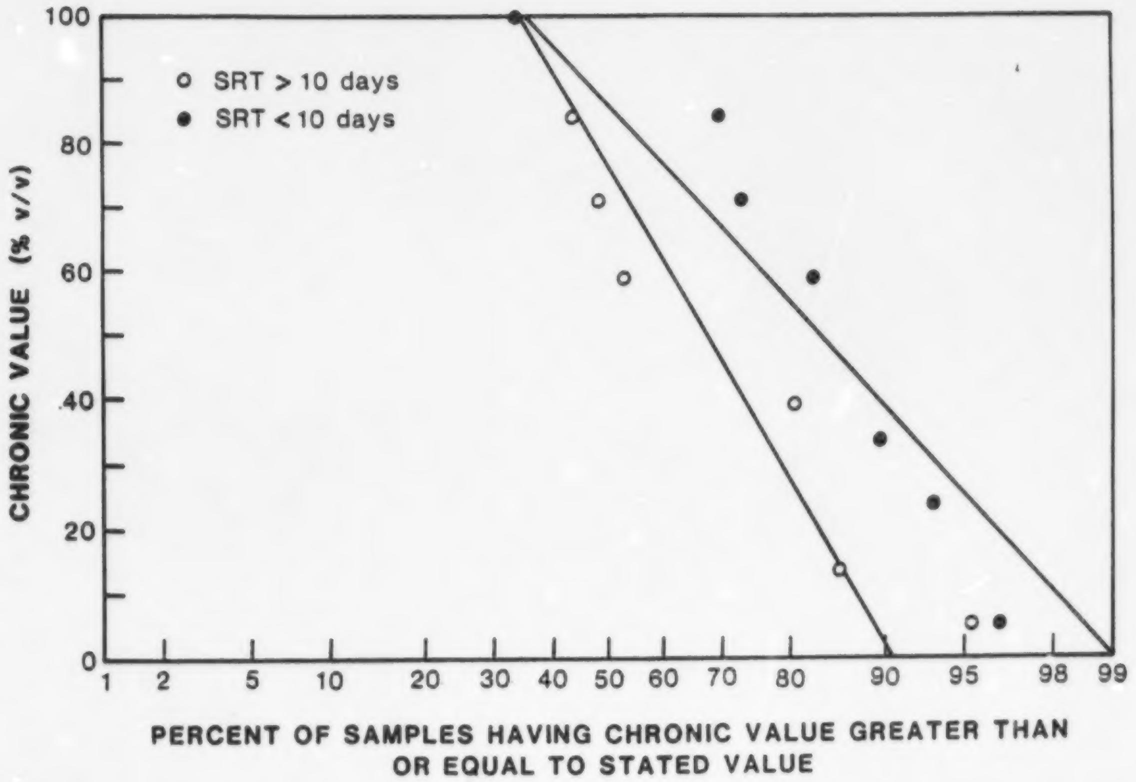
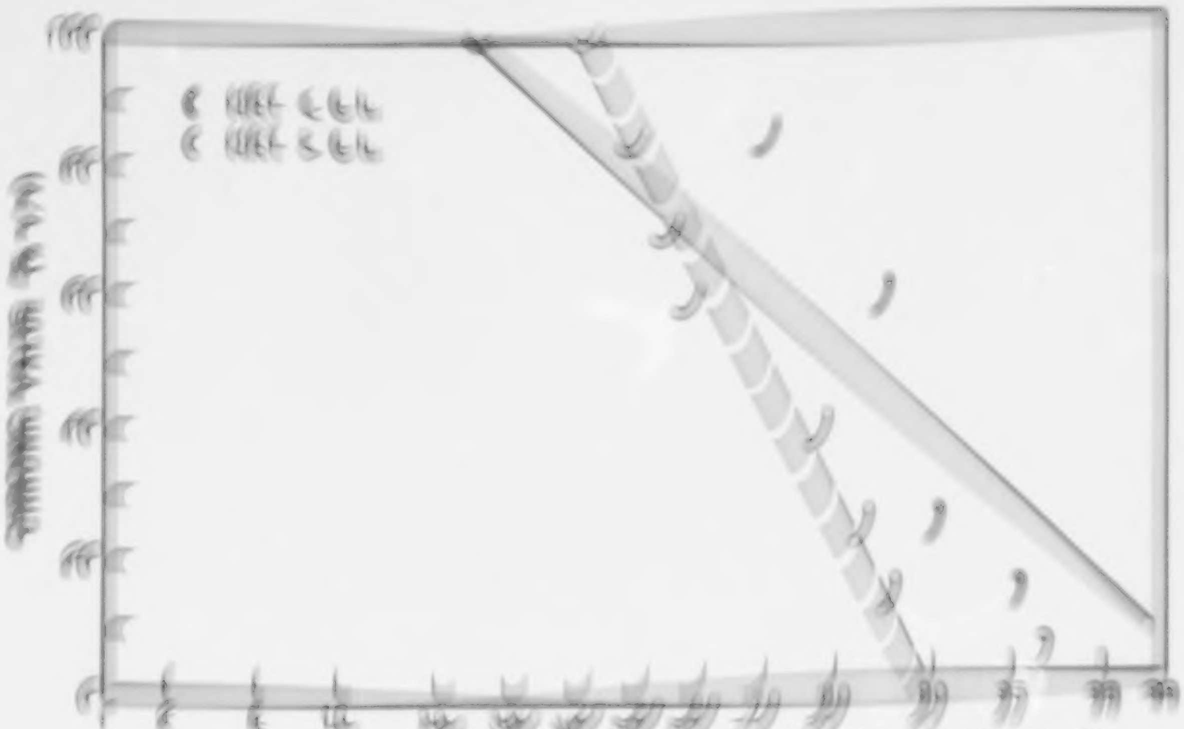


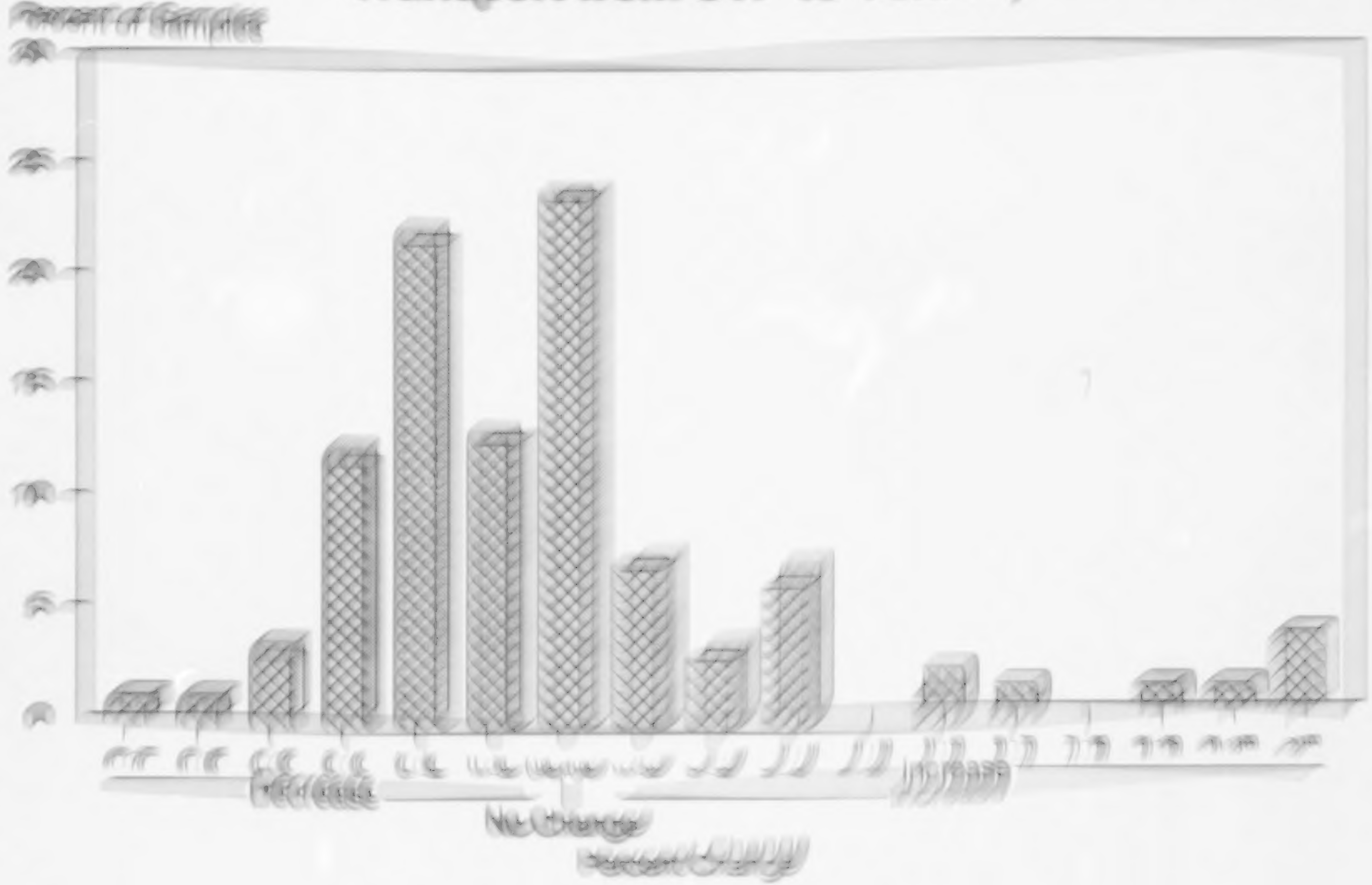
FIGURE 6.44. EFFECT OF SRT ON FATHEAD MINNOW TOXICITY



PERCENT OF SAMPLES HAVING CHRONIC VALUE GREATER THAN OR EQUAL TO STATED VALUE

FIGURE 4.48 EFFECT OF AERATION TANK HRT ON EFFLUENT CHRONIC TOXICITY

Figure 4.24 Change in Effluent Total Ammonia During Sample Transport from STP to Toxicity Laboratory



generally related to samples with total ammonia values approaching the method detection limit (e.g., samples with total ammonia of less than 1 mg/L) and, therefore, analytical accuracy would be reduced. Eighty-eight percent of samples showed total ammonia levels within ± 10% initial values. A decrease of 11% to 50% occurred in 50% of samples. An increase of 11% to 50% of initial ammonia levels occurred in 17% of samples, but most such occurrences were associated with STP samples which were collected early in the study when comparability between field and laboratory analyses was less well-established.

Residual Chlorine

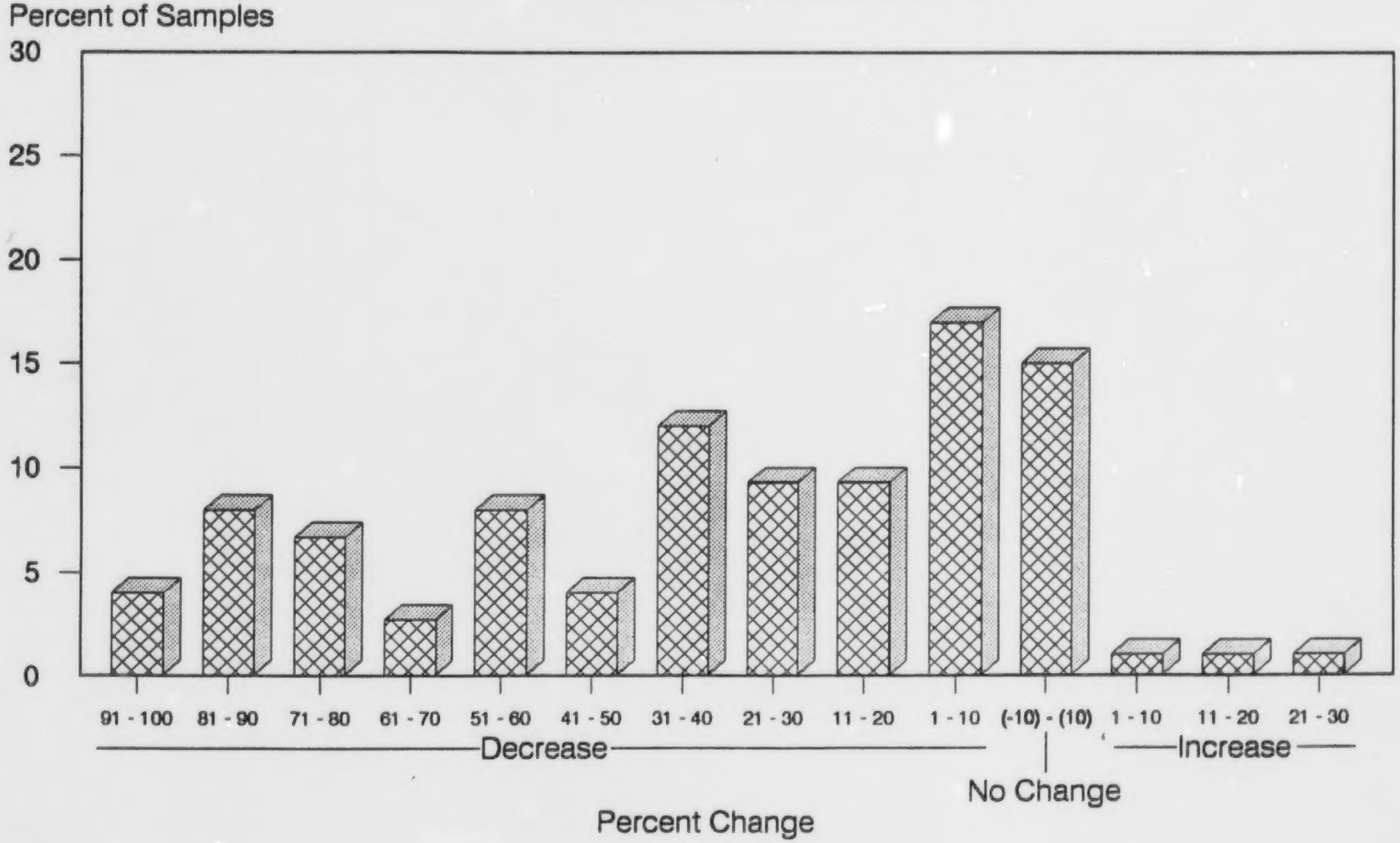
Although free residual chlorine (FRC) was occasionally detected in effluent samples immediately after collection (detected in 17 of 78 samples, maximum concentration 0.13 mg/L (Toronto North, winter); detection limit 0.01 mg/L), it was not detected in any samples after arrival at the toxicity laboratory.

Total residual chlorine declined in 61 of 75 samples (81%) in which chlorine was measured (Figure 7.23). Fifteen percent of samples showed no change in TRC during sample transport. In three samples (4%), TRC appeared to increase, but this was likely a result of analytical inaccuracy.

Implications

These changes in sample chemistry underline the necessity for prompt delivery and test initiation in the assessment of STP effluent toxicity. For those effluents in which both ammonia and residual chlorine are important toxicants (Section [illegible]), effluent toxicity is likely to be increasingly underestimated as the delay between sample collection and testing is increased. Since both parameters tended to decrease even during the short period of time between sample collection and delivery (usually less than eight hours) in this study.

Figure 4.25 Change in Effluent Total Residual Chlorine During Sample Transport from STP to Toxicity Laboratory



### 4.2.2 During Toxicity Testing

pH

Almost all samples showed different pH at the end of the test, relative to initial pH. In acute tests (two to four days) using rainbow trout and *D. magna*, the majority of samples showed pH increases of 0.5 to 1.0 units (Figures 4.26 and 4.27). In the chronic fathead minnow tests, the difference in final relative to initial sample pH was slightly more variable, but typically showed an increase over the seven-day tests (Figure 4.28). Sample pH changes in *C. dubia* tests ranged from a decrease of 1.0 unit to an increase of 1.9 units, although the pH difference in the majority of samples ranged from a decrease of 0.01 unit to an increase of 1.0 unit (Figure 4.29).

Nitrogen Speciation

Fifty-two percent of effluent samples showed little or no change in total ammonia-nitrogen ($NH_3$) levels (± 10% of initial) during the four-day rainbow trout test (Figure 4.30). In approximately 33% of test solutions, $NH_3$ appeared to increase. Most samples (81%) had total ammonia levels at the end of the test which were within ± 40% of initial levels.

A large percentage of test solutions also showed little change in nitrate($NO_3$)- (64%) or nitrite($NO_2$)- (42%) nitrogen during the four-day trout test. $NO_2$ increases of more than 10% of initial levels occurred in 39% of samples, while $NO_3$ increased in only 10% of samples. Final $NO_2$ and $NO_3$ concentrations were within ± 40% of initial levels in 76% and 88% of samples, respectively.

Effluent sample nitrogen changed more dramatically during the seven-day fathead minnow tests (Figure 4.31). Total $NH_3$ was essentially unchanged in 26% of samples at the end of the test, while 54% of samples showed a decrease of 10 to 90% of initial $NH_3$ concentrations. $NO_2$ concentrations, however, increased by more than 100% in 62% of all test solutions. Thirty percent of test solutions also showed increases of more than 100% of initial $NO_3$ levels, while 30% remained unchanged. In only 9% of samples did $NO_2$ and $NO_3$, respectively, decrease by more than 10% of initial levels.

## Figure 4.26 Change in Sample pH Between Beginning and End of Acute Rainbow Trout Tests

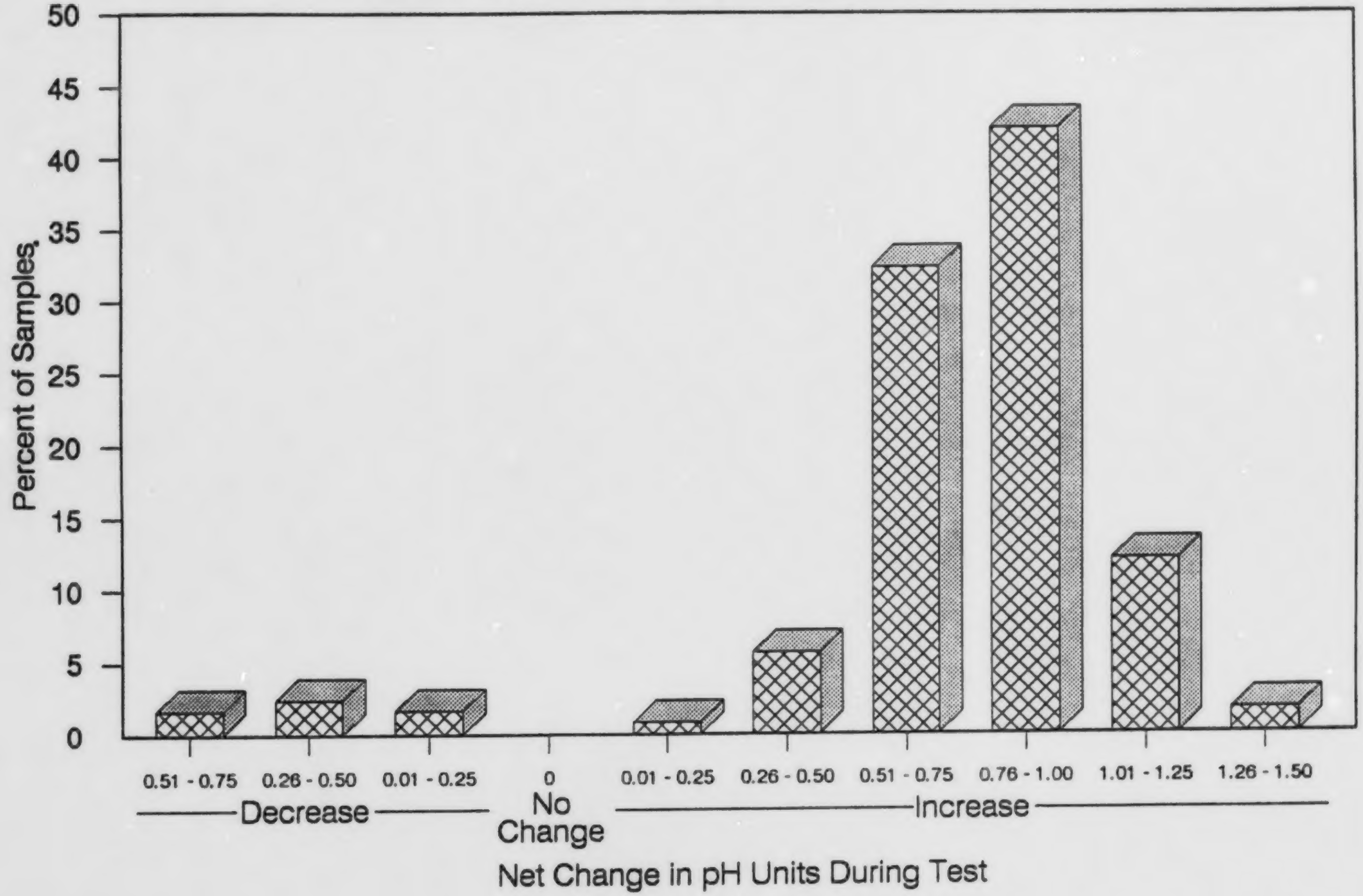
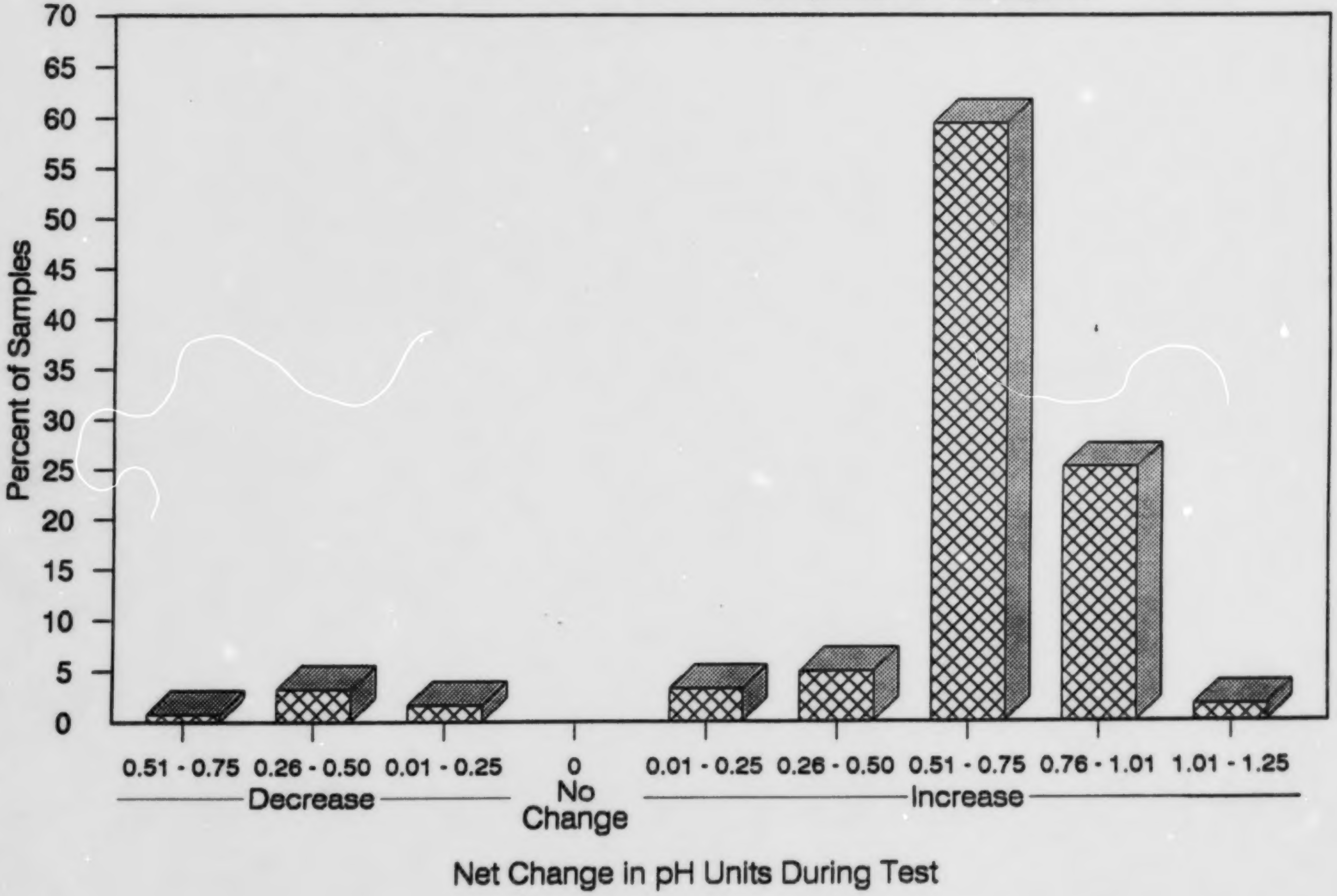


Figure 4.27 Change in Sample pH Between Beginning and End of Acute *Daphnia magna* Tests



## Figure 4.28 Change in Sample pH Between Beginning and End of Chronic Fathead Minnow Tests

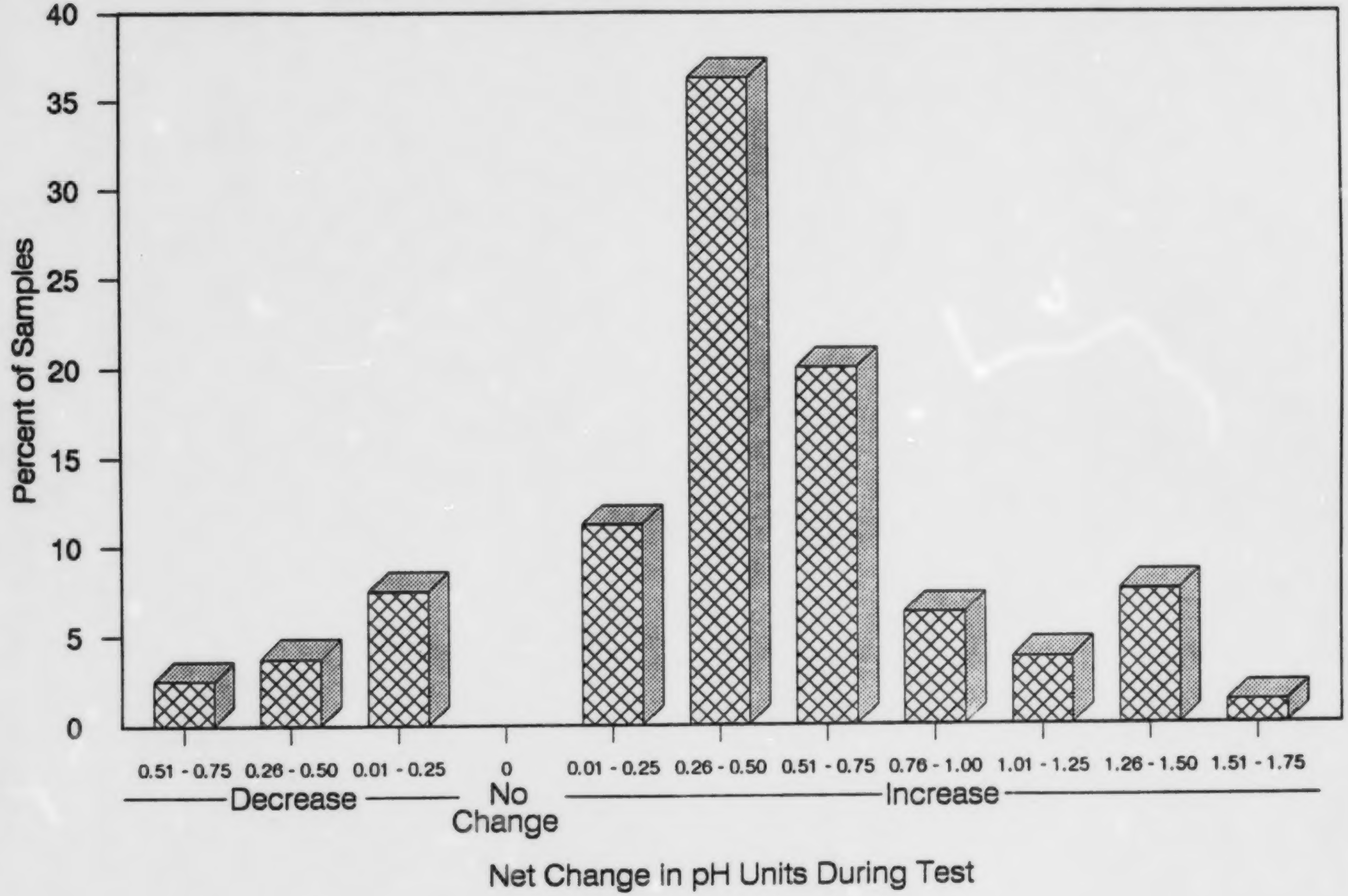


Figure 4.29 Change in Sample pH Between Beginning and End of Chronic _C._ _dubia_ Tests

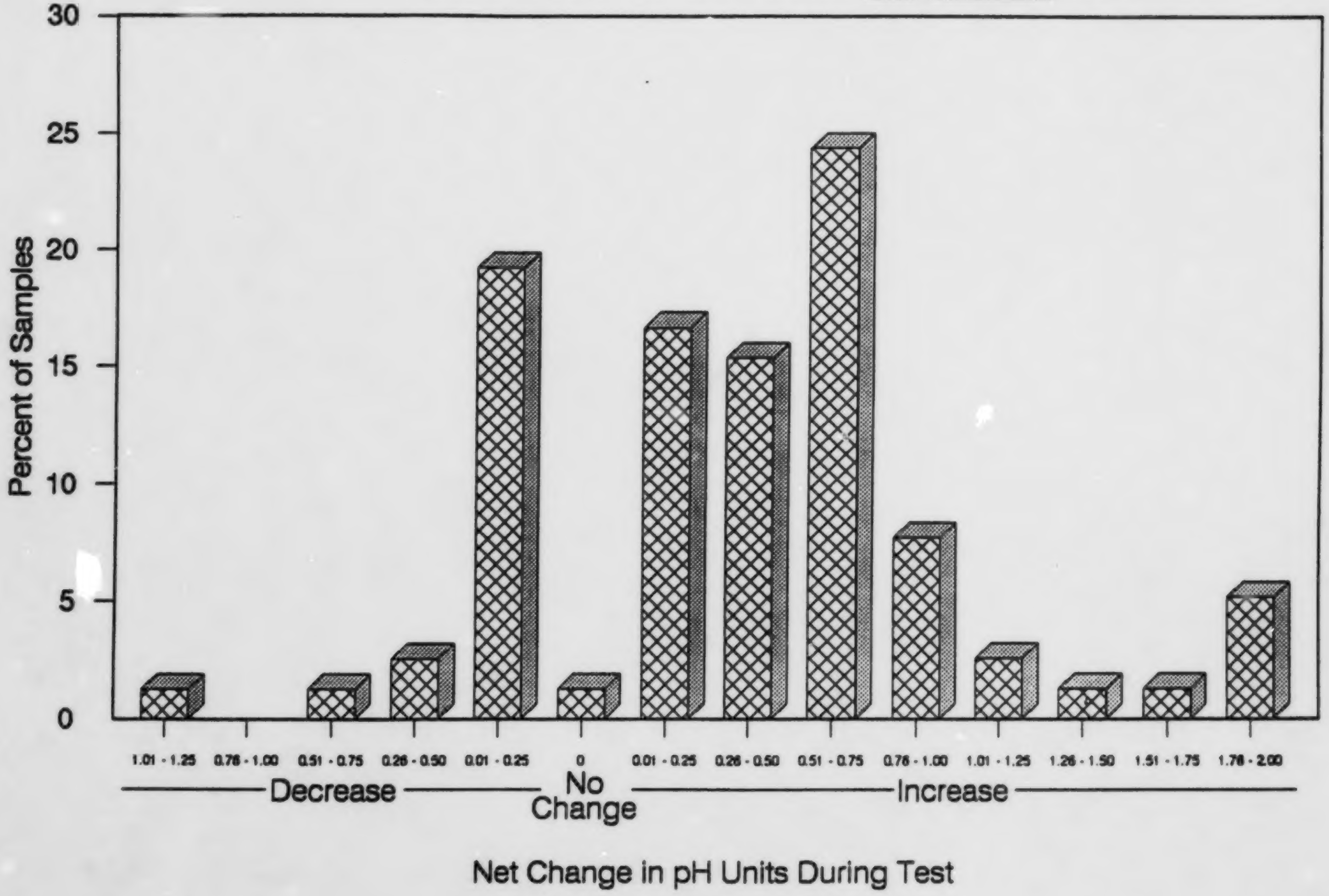
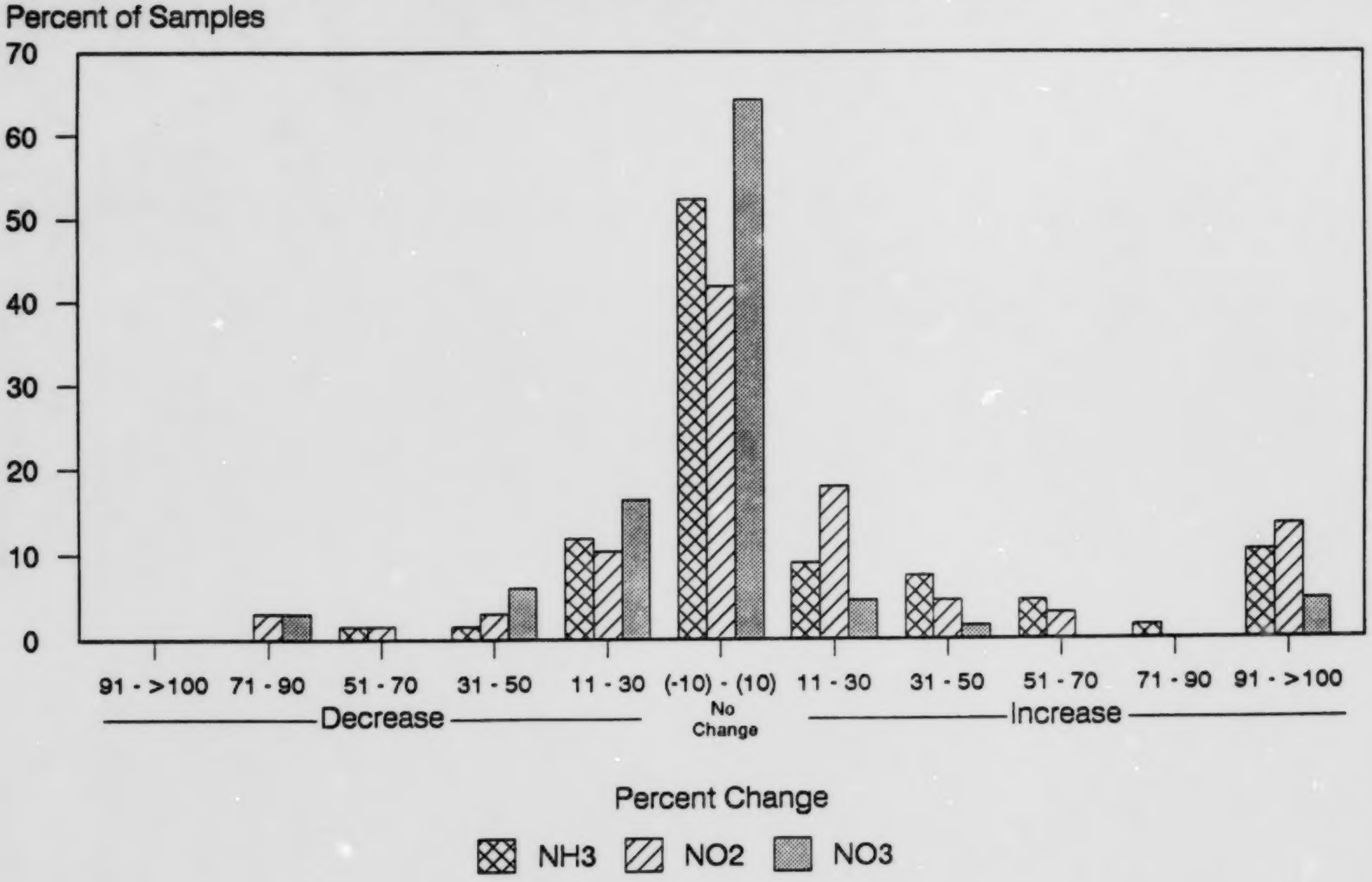
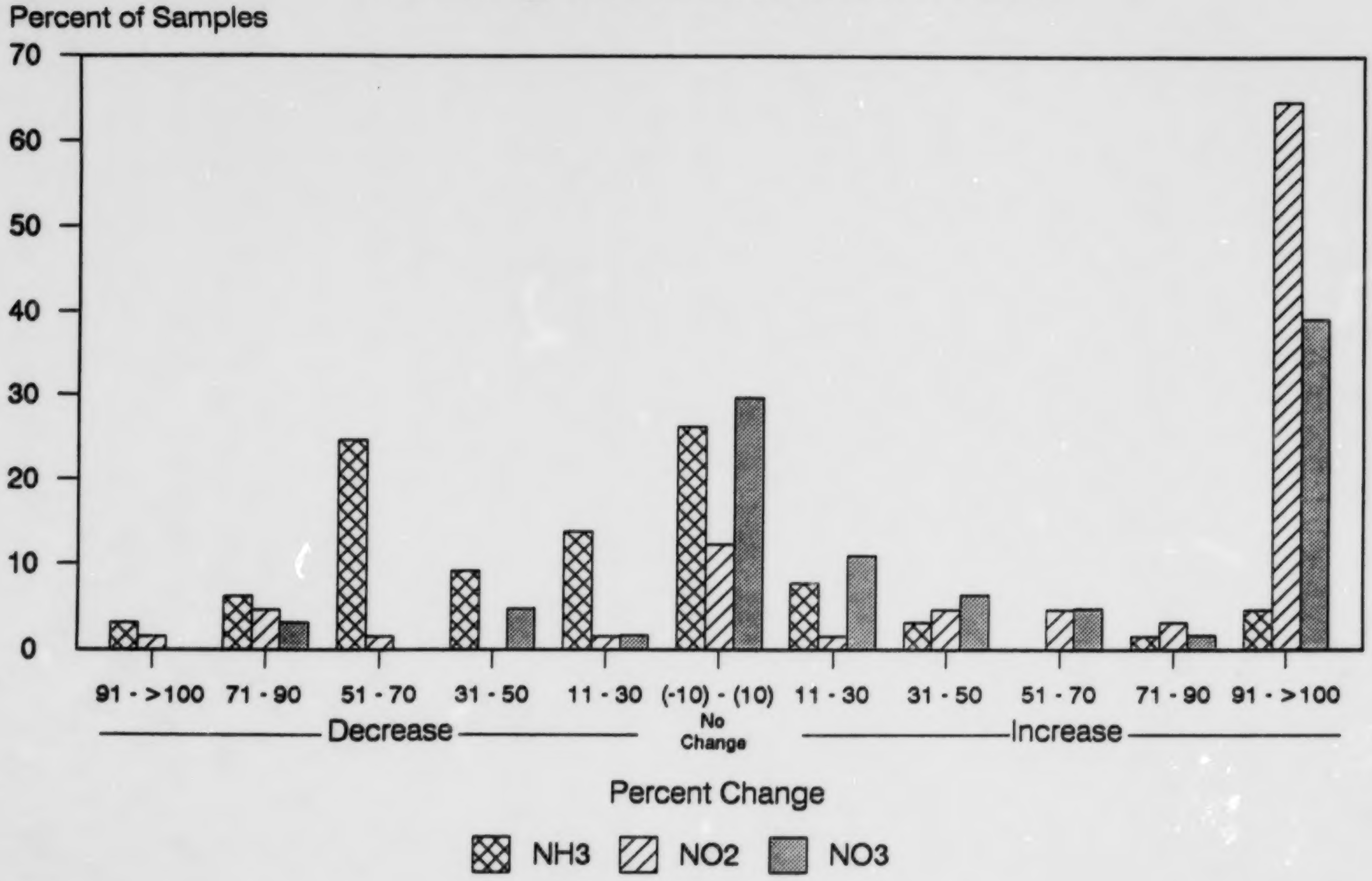


Figure 4.30 Changes in Effluent Sample Nitrogen During Rainbow Trout Tests



## Figure 4.31 Changes in Effluent Sample Nitrogen During Fathead Minnow Tests



Concentrations of sample $NH_3$, $NO_3$ and $NO_2$ were not measured at the end of the daphnid tests.

Un-ionized ammonia represents the toxic form of ammonia (U.S. EPA, 1985a), and the proportion of un-ionized versus ionized ammonia (ammonium) in solution is dependent on sample pH and temperature (Emerson et al., 1975). Since pH and total ammonia levels changed during the toxicity tests, it seemed likely that un-ionized ammonia levels were not constant.

Figure 4.32 indicates that un-ionized ammonia concentrations increased dramatically during rainbow trout tests. The separation of data into three arbitrarily selected categories of initial pH values demonstrates that extreme changes (e.g., increases of more than ten times original levels) were largely based on samples with very low initial un-ionized ammonia (i.e., small increases on an absolute basis represented a large percentage change with respect to initial value). Nevertheless, increases of two to eight times the initial un-ionized ammonia concentration were common.

Increased un-ionized ammonia concentrations during fathead minnow tests also frequently occurred, although, except for samples with very low initial concentrations, most increases represented less than four times the initial concentration (Figure 4.33). More than 25% of samples showed a decrease in un-ionized ammonia by the end of the test.

## Implications

For those effluents containing toxic concentrations of a nitrogen compound (see Section 4.4), changes in nitrogen speciation during toxicity tests may be expected to impact on toxicity test results. This will also be true for effluents containing toxic levels of other chemicals (not specifically evaluated in this study) which do not remain stable over the test duration. Changes in other effluent properties (e.g., pH) that may affect the expression of a chemical's toxicity (Sprague, 1985) can further complicate interpretation of test results.

Figure 4.32 Change in Un-ionized Ammonia Concentrations Between Beginning and End of Acute Rainbow Trout Tests

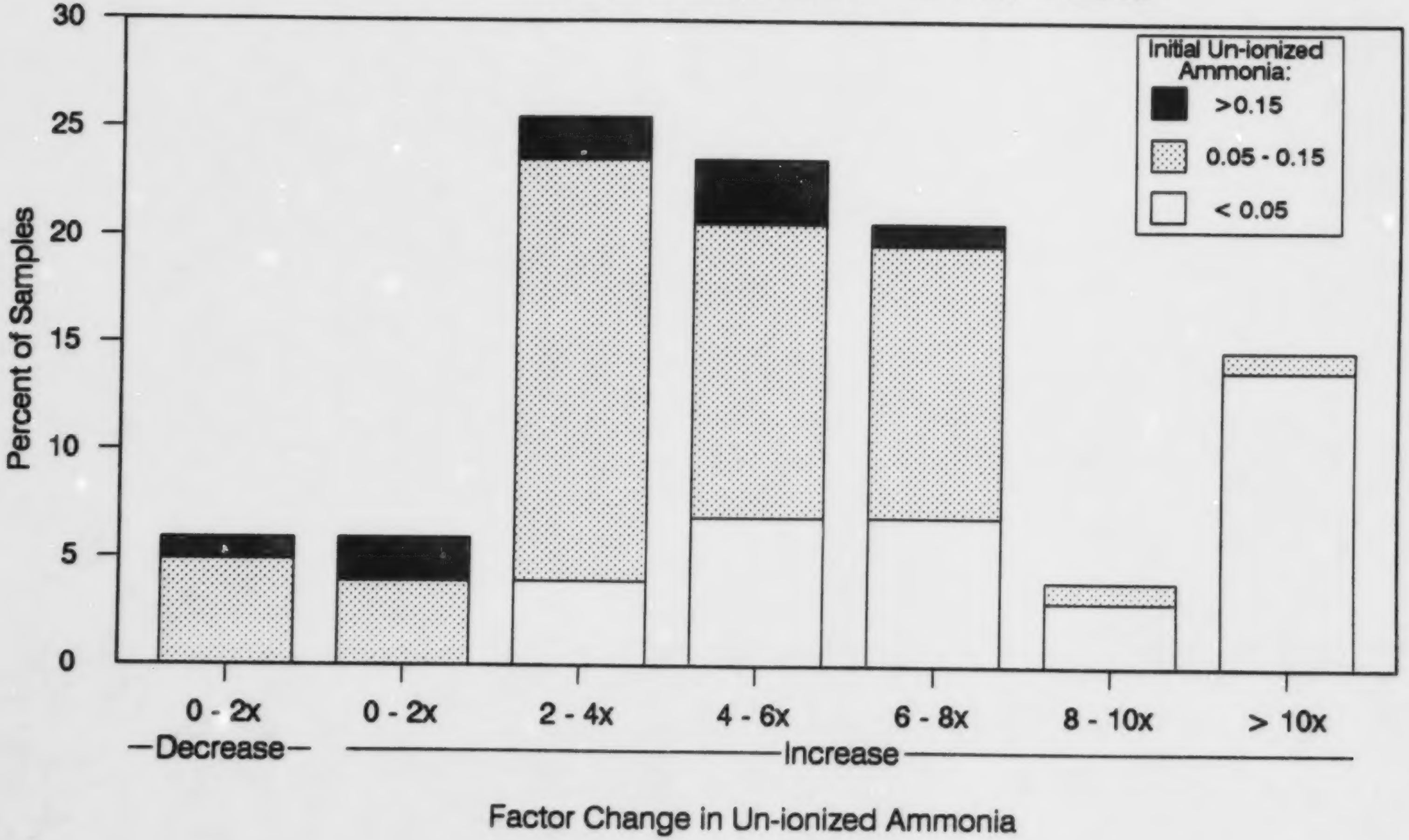
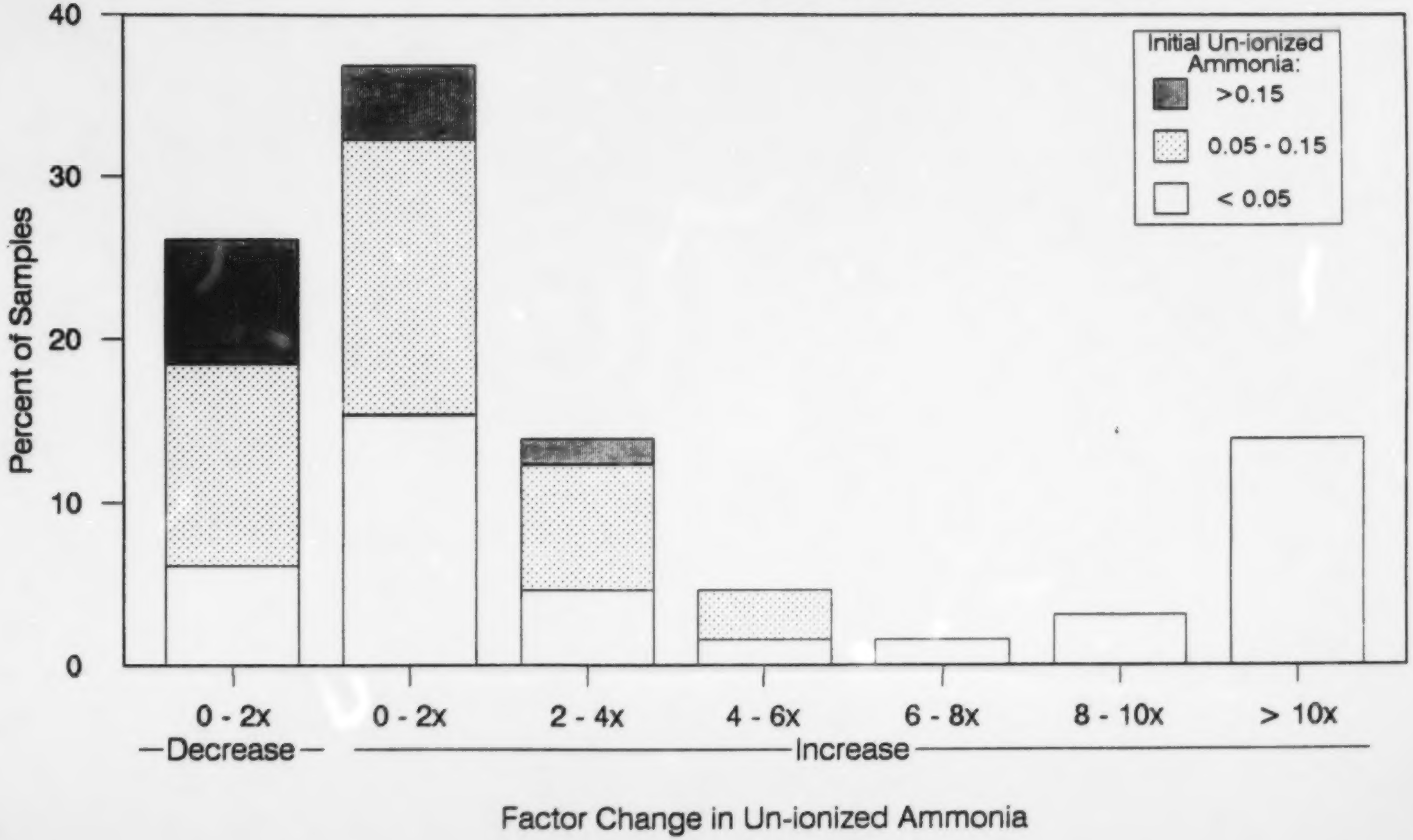


**Figure 4.33 Change in Un-ionized Ammonia Concentrations Between Beginning and End of Chronic Fathead Minnow Tests**



## 4.3 Inter-Species Toxicity Comparison

### 4.3.1 Rainbow Trout and Daphnia magna

Comparison of acute toxicity of STP effluents to rainbow trout and Daphnia magna (as received plus dechlorinated samples) did not demonstrate any consistent trends (Figure 4.34). Of the samples that were lethal to both trout and D. magna, the daphnids showed greatest sensitivity as indicated by the higher proportion of samples under the 1:1 line on Figure 4.34. However, a greater proportion of the samples tended to be lethal to trout than to D. magna (Section 3.1.1). Only a small number of samples were lethal to daphnids, while also non-lethal to trout.

### 4.3.2 Fathead Minnow and Ceriodaphnia dubia

Comparison of lethal test results using fathead minnows and C. dubia indicated no consistent relationship, although the STP effluents tended to be more lethal to C. dubia than minnows (Figure 4.35). Sublethal effect concentrations for both species were distributed across all concentrations with no consistent relationship between species on any given sample (Figure 4.36).

### 4.3.3 Implications

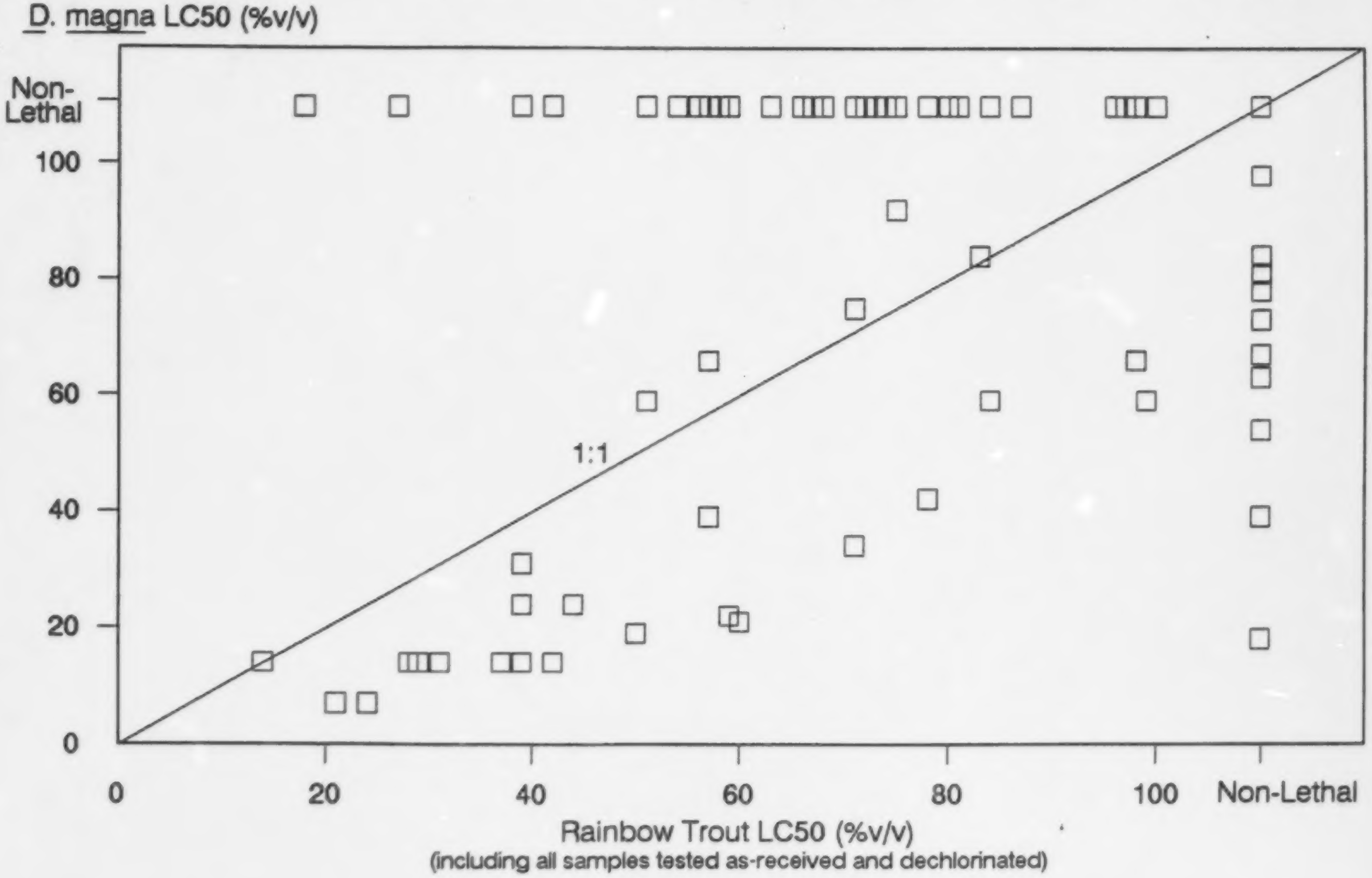
Differences in response between species demonstrates the need for multi-species evaluations of effluents for regulation of toxic discharges. Different organisms respond in differing degrees and to different contaminants in a complex matrix. Regulations based on the response of a single species will not ensure adequate protection for other aquatic species.

## 4.4 Principal Toxicants

### 4.4.1 Correlation and Regression Analyses

Statistical analyses were performed using SPSS (SPSS/PC+, Version 3.1, SPSS Inc., 444 N. Michigan Ave., Chicago, IL). Initially, correlations were performed to identify statistically significant relationships between chemical levels and toxicity test results.

**Figure 4.34 Comparison Between STP Effluent Toxicity to Rainbow Trout and Dapnia magna for Each Sample**



## Figure 4.35 Comparison Between Chronic LC50 Results Generated for Each STP Sample Using Fathead Minnow and C. dubia

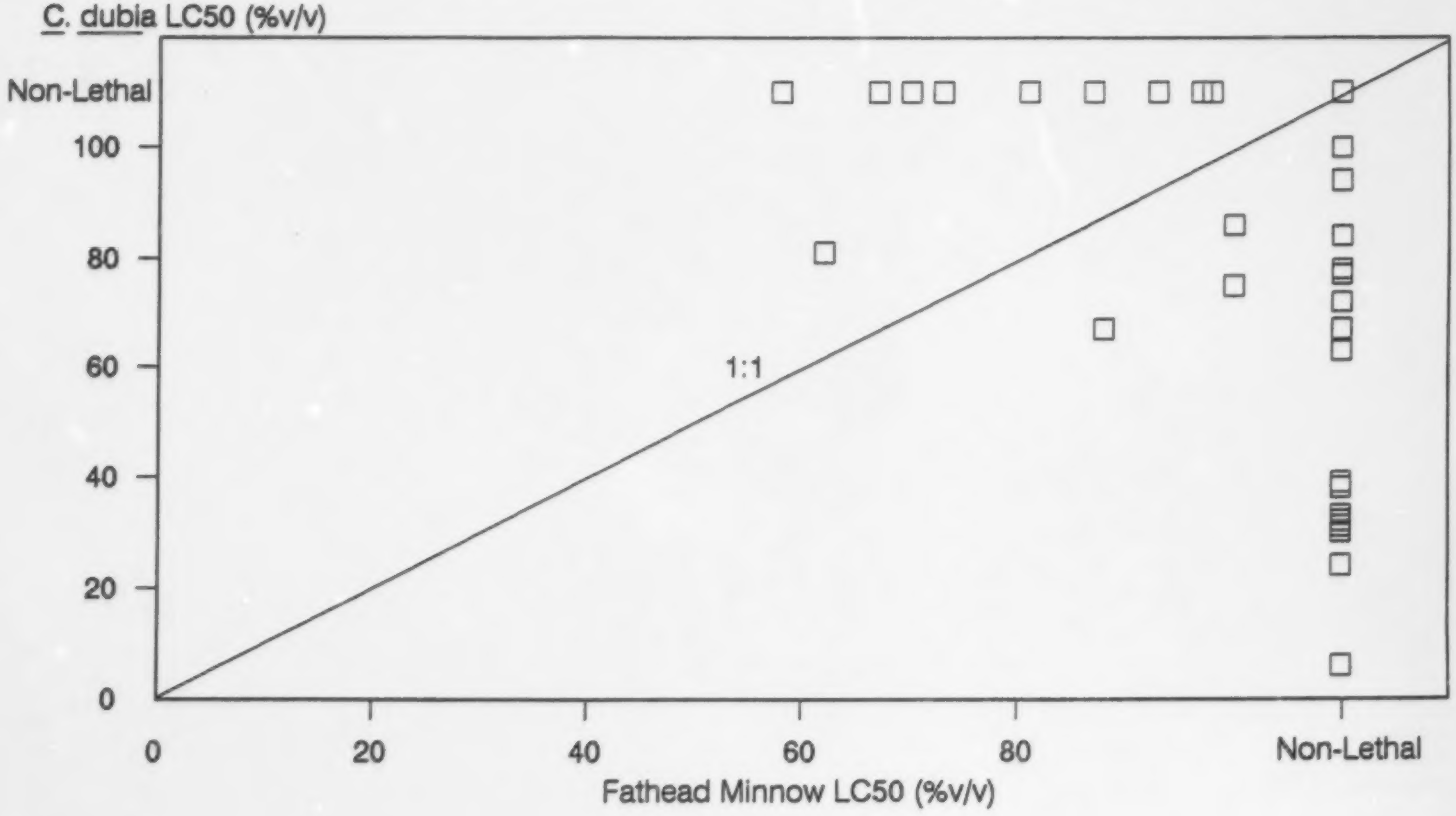
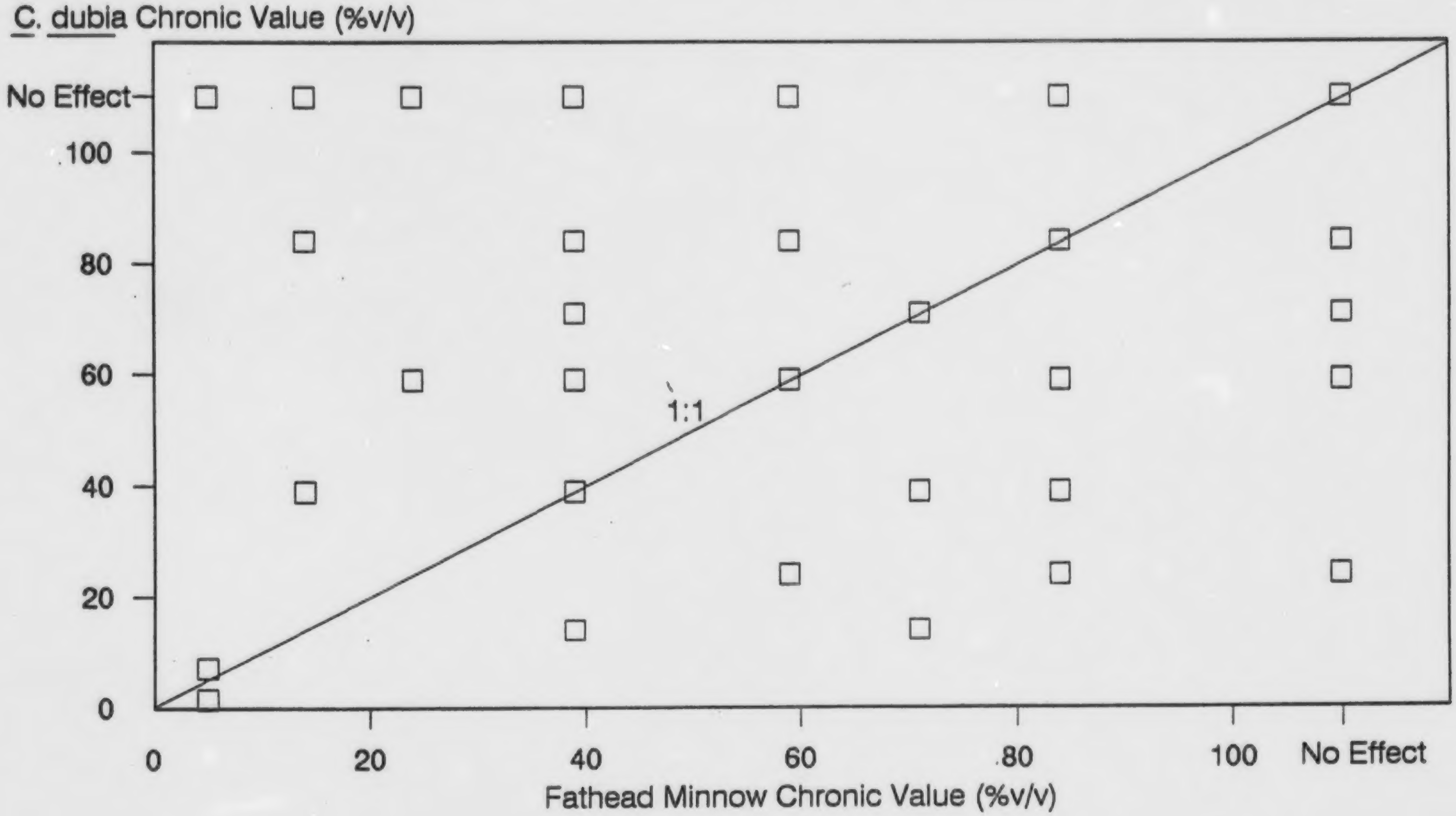


Figure 4.36 Comparison Between Chronic Values Generated for Each STP Sample Using Fathead Minnow and _C._ _dubia_ Tests



Review of the kurtosis and skewness associated with the chemistry and toxicity data indicated that much of the data were non-normally distributed. Therefore non-parametric correlation coefficients were calculated based on ranks (Spearman Correlation). Since ranks were used, the value assigned to censored data (i.e., effect concentrations of greater than 100% effluent and chemical levels below the method detection limit (MDL)) had no effect on the statistical outcome, provided that they were given a value appropriate to their rank in the data set. Non-toxic samples were thus assigned a value of 150 and chemical parameters that were not measured at detectable levels were assigned a value of one-half the MDL.

For each test type, the data set was reviewed as a whole, then divided into sub-sets for comparative analysis (e.g., summer versus winter data, filtered versus non-filtered metal concentrations, including or excluding no-effect data).

Only metals and major ions were re-analyzed in filtered samples. In order to consider the relative importance other effluent parameters in filtered samples, it was necessary to assume that the concentrations of those un-measured parameters ($NH_3$, $NO_3$, $NO_2$, TRC, etc.) were the same as in non-filtered samples for regression analyses.

Significant correlation between effluent toxicity and a chemical parameter does not necessarily indicate a cause-effect relationship. Correlation analyses were, however, reviewed to identify those parameters which were unlikely related to toxicity. For example, a positive correlation suggested no dose-response relationship, and the parameter was then excluded from subsequent multiple regression analysis. Non-specific parameters such as BOD, DOC, TSS and VSS were exceptions, in that either a positive or negative correlation might be expected, depending on the contaminants that each parameter represented. These parameters were therefore included in all subsequent regression analyses. Calcium and magnesium were expected to have an ameliorating effect on other contaminants present, rather than a toxic action (Sprague, 1985) and were eliminated from further analysis if they demonstrated a negative correlation.

Multiple regression analyses were then performed to identify which contaminants best explained the variability in toxicity test results. Two distinct sets of regression analyses were performed on acute toxicity data. In the first set, chemical and toxicity data from samples tested as-received were included in the evaluation. In the second set, only data from samples containing low TRC were evaluated. That is, of samples which were split for dechlorination, only data from the dechlorinated sample were considered. Because TRC was low or non-detectable in all samples in this data set, it was not included among the chemical parameters to be evaluated. The distinction between the two data sets was made for two reasons:

- measurable effluent TRC levels are a result of the addition of chlorine to the effluent prior to discharge; the concentration of TRC in an effluent is therefore independent of the other aspects of STP operating performance; while it was important to evaluate the relative contribution of TRC to acute toxicity, it could be considered independent of other effluent contaminants; and
- when dechlorination of a sample was required, chronic tests were performed on dechlorinated samples only; evaluation of low-TRC samples permitted more thorough evaluation of toxicants other than TRC and represented a more direct comparison to chronic test results.

### 4.4.2 Comparison to Documented Toxic Concentrations

With the exception of TRC and ammonia, STPs were not necessarily expected to discharge similar types of contaminants, since each received wastewaters of differing composition. This would possibly result in insufficient available data for any given parameter to identify a relationship between effluent concentration and toxicity. Consequently, it was desirable to independently evaluate the chemisty data for each STP in relation to known toxic levels for each chemical.

In addition, while regression analyses indicated those chemical variables which could be used to explain the variability in toxicity test data, cause and effect could not be concluded. Review reports, such as water quality objective development documents, were used to obtain, or estimate, toxic concentrations of individual effluent parameters to the four test organisms used in the study (Appendix D). The data presented in Appendix D do not include organic parameters, since very few were found at detectable levels (Section 3.3, 4.4.7).

It should be noted that the toxicity values presented in Appendix D for each chemical were selected, using professional judgement, from a range of values reported based on pure chemical tests conducted under controlled conditions. The actual toxicity of any single parameter contained in a complex effluent may be markedly altered by the presence of other constituents of the effluent (Marking, 1985).

Few data were available in the literature to describe the chronic toxicity of the specific contaminants. Where no data were available in the literature for a particular contaminant, a chronic value was typically estimated by multiplying the best available acute data by a fraction. For example, fathead minnow chronic data were frequently estimated from acute trout data. The estimation of an appropriate multiplication factor (typically in the range of 0.1 to 0.01) involved professional judgement and was based, whenever possible, on other available data (e.g., the acute-chronic ratio for trout and/or the relationship between trout and minnow LC50s).

The toxic concentrations of each parameter were compared against the chemical concentrations measured in effluents and corresponding toxicity test results for each test organism. The evaluation focussed on those contaminants that were measured in effluent samples at levels exceeding toxic concentrations and those chemicals that were identified as possible toxicants in regression analysis.

### 4.4.3 Rainbow Trout

#### 4.4.3.1 Regression Analyses

Each $R^2$ value in Table 4.4 reflects the degree to which the variability in toxicity test data was explained by the variablity in concentration of all the chemical parameters included in the regression to that point.

TRC concentrations were most strongly correlated with rainbow trout toxicity of samples tested as received, and accounted for 25% to 43% of the variability in toxicity test results (ie., depending on the data set examined, Table 4.4). Various other parameters, particularly un-ionized ammonia and dissolved organic carbon (DOC), seemed to account for some of the variability observed in toxicity test results that could not be attributed to TRC.

TABLE 4.4: MULTIPLE REGRESSION ANALYSIS[a] OF STP EFFLUENT CHEMISTRY VERSUS ACUTE TOXICITY TO RAINBOW TROUT

| Number | Data Set<br>Data Included[b] | No. of Samples Considered | First Parameter | $R^2$ | Second Parameter | $R^2$ | Third Parameter | $R^2$ | Fourth Parameter | $R^2$ | Fifth Parameter | $R^2$ | Sixth Parameter | $R^2$ | Seventh Parameter | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Samples As-Received** | | | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 120 | TRC | 0.25[b] | $NH_3$ | 0.45 | Al | 0.54 | Se | 0.55 | | | | | | |
| 2 | L and N, S and W, F | 118 | TRC | 0.25 | $NH_3$ | 0.45 | Al | 0.56 | | | | | | | | |
| 3 | L and N, S, M | 59 | TRC | 0.43 | $NH_3$ | 0.69 | DOC | 0.72 | | | | | | | | |
| 4 | L and N, S, F | 57 | TRC | 0.42 | $NH_3$ | 0.68 | DOC | 0.71 | | | | | | | | |
| 5 | L and N, W, M | 61 | DOC | 0.41 | TRC | 0.46 | $NO_2$ | 0.54 | | | | | | | | |
| 6 | L and N, W, F | 61 | DOC | 0.41 | TRC | 0.46 | Cu | 0.54 | | | | | | | | |
| 7 | L, S and W, M | 44 | TRC | 0.41 | Hg | 0.46 | Al | 0.51 | | | | | | | | |
| 8 | L, S and W, F | 68 | TRC | 0.38 | Al | 0.44 | TSS | 0.47 | | | | | | | | |
| 9 | L, S, F | 24 | TRC | 0.37 | Mn | 0.45 | Mg | 0.55 | | | | | | | | |
| 10 | L, W, F | 44 | TRC | 0.41 | Al | 0.48 | | | | | | | | | | |
| 11 | L, S, M | 69 | TRC | 0.37 | Al | 0.43 | Hg | 0.47 | | | | | | | | |
| 12 | L, W, M | 44 | TRC | 0.41 | Hg | 0.46 | Al | 0.51 | | | | | | | | |
| **Low TRC Samples Only** | | | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 120 | $NH_3$[c] | 0.33 | Al | 0.36 | Sr | 0.42 | BOD | 0.44 | Mo | 0.46 | DOC | 0.49 | | |
| 2 | L and N, S and W, F | 119 | $NH_3$ | 0.33 | Sr | 0.36 | Al | 0.39 | BOD | 0.43 | DOC | 0.46 | Ni | 0.48 | As | 0.50 |
| 3 | L and N, S, M | 59 | $NH_3$ | 0.29 | TSS | 0.38 | Al | 0.44 | | | | | | | | |
| 4 | L and N, S, F | 57 | $NH_3$ | 0.28 | TSS | 0.36 | Al | 0.43 | BOD | 0.51 | | | | | | |
| 5 | L and N, W, M | 61 | DOC | 0.44 | Mn | 0.54 | Mo | 0.58 | $NH_3$ | 0.61 | | | | | | |
| 6 | L and N, W, F | 61 | DOC | 0.44 | BOD | 0.52 | | | | | | | | | | |
| 7 | L, S and W, M | 53 | DOC | 0.21 | BOD | 0.29 | Ca | 0.35 | | | | | | | | |
| 8 | L, S and W, F | 52 | DOC | 0.17 | BOD | 0.26 | | | | | | | | | | |
| 9 | L, S, F | 12 | BOD | 0.36 | | | | | | | | | | | | |
| 10 | L, W, F | 40 | DOC | 0.22 | BOD | 0.30 | | | | | | | | | | |
| 11 | L, S, M | 13 | Sr | 0.42 | | | | | | | | | | | | |
| 12 | L, W, M | 40 | DOC | 0.22 | BOD | 0.30 | | | | | | | | | | |

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[a] L - lethal, N - non-lethal, S - summer, W - winter, M - total metal concentrations, F - filtered metal concentrations.

[b] Each $R^2$ reflects the degree to which variability toxicity data are explained by variability in concentration of all the chemical parameters included in the regression to that point.

[c] $NH_3$ expressed as un-ionized; estimated from temperature, pH and total ammonia levels measured at initiation of the test.

In order to more effectively identify the effects of toxicants other than TRC, regressions were performed on the data from samples containing TRC concentrations of less than 0.01 mg/L.

Un-ionized ammonia concentrations best explained the variability in toxicity of low-TRC samples, except when only winter samples and/or lethal samples were considered. Possible reasons for the exceptions are discussed in the following section (4.4.3.2).

Inclusion of aluminum, strontium, molybdenum, arsenic, nickel, total suspended solids, manganese, and calcium concentrations of various data sets explained between 30% and 61% of observed variability in effluent lethality to rainbow trout among low-TRC samples. As mentioned previously (Section 4.4.2), cause and effect could not be concluded from regression analysis, nor could it be assumed that regression analyses would identify all toxicants. Therefore, measured chemical concentrations for lethal versus non-lethal samples were compared to toxicity data reported in the literature.

#### 4.4.3.2 Parameter-Specific Evaluation

An estimate of the toxic concentration of each contaminant to rainbow trout was obtained from the literature (Appendix Table D.1). These concentrations were compared to levels measured in each effluent sample. Where a contaminant was found to exceed the trout LC50, it was noted whether or not the sample had indeed been lethal to trout (Table 4.5). Table 4.5 also includes additional parameters which were identified as potentially important toxicants in regression analyses.

A strong dose-response relationship between TRC and rainbow trout LC50s is supported by the data in Figure 4.37. Concentrations of TRC above about 0.2 mg/L were usually lethal. This value is higher than the mean acute LC50 value of 0.06 mg/L reported by the U.S. EPA (1985b) for rainbow trout, but can likely be attributed to dissipation of TRC during the static, aerated tests of this study, in contrast to the continuous-flow test results used to derive the EPA value.

For the rainbow trout tests, the standard test temperature of 15°C and initial test pH values were used to calculate un-ionized ammonia concentrations from measured total ammonia concentrations (Emerson et al., 1975). Of 40 samples in which un-ionized

**TABLE 4.5:** COMPARISON OF STP EFFLUENT CHEMISTRY[a] TO CONCENTRATIONS REPORTED AS LETHAL TO RAINBOW TROUT

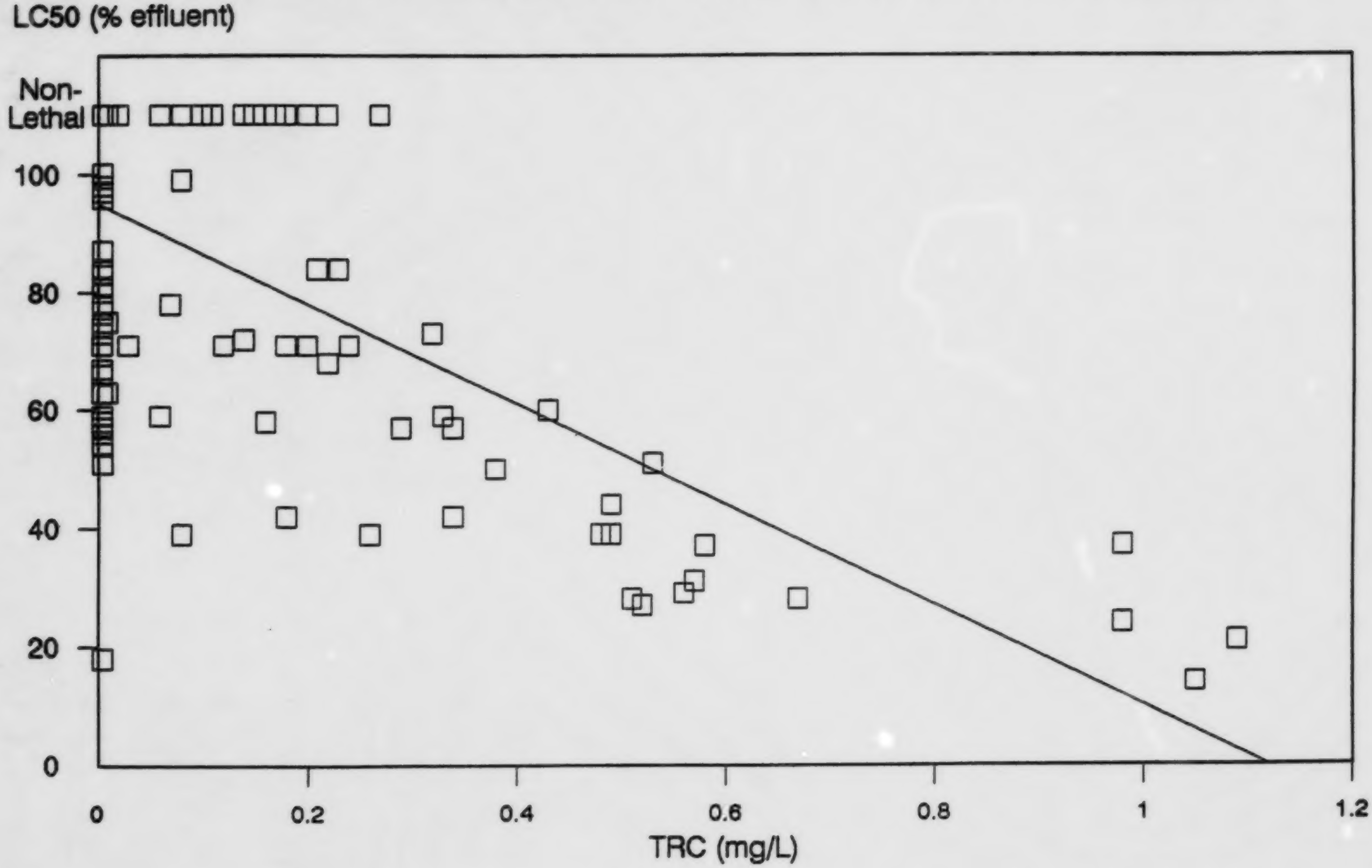
| Parameter | Approximate LC50 (mg/L)[b] | Number Samples With Toxicant Concentration Exceeding LC50 | | Number Samples With Toxicant Concentration Exceeding LC50 and Sample was Lethal | | Comments |
|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Ag | 0.010 | 2 | 0 | 2 | - | MDL[d] was 10 times greater than LC50 |
| Al | 5.0 | 0 | 0 | - | - | 7 of 9 samples containing non-filtered Al at levels greater than 1.0 mg/L were lethal |
| As | 13 | 0 | 0 | - | - | All As concentrations were 3 orders magnitude or more below LC50 and frequently less than MDL |
| Cd | 0.0036 | 0 | 1 | - | 0 | MDL was 28 times greater than LC50; filtered Cd value exceeded total Cd when detected and was therefore suspect |
| Co | 0.48 | 0 | 0 | | | Most samples did not contain detectable cobalt and, in those where cobalt was detected, concentrations were 1 to 2 orders magnitude below LC50 |
| Cu | 0.11 | 3 | 2 | 2 | 2 | 10 of 15 samples with non-filtered Cu that exceeded 0.07 mg/L were lethal; 11 of 16 samples with filtered Cu that exceeded 0.07 mg/L were lethal; of the 5 non-lethal samples with filtered Cu exceeding 0.07, chemistry of 4 were questionable since reported filtered Cu exceeded total Cu concentration |
| Hg | 0.270 | 0 | 0 | - | - | Highest measured Hg concentration was more than two orders magnitude below LC50 |

**TABLE 4.5:** (cont'd) COMPARISON OF STP EFFLUENT CHEMISTRY[a] TO CONCENTRATIONS REPORTED AS LETHAL TO RAINBOW TROUT

| Parameter | Approximate LC50 (mg/L)[b] | Number Samples With Toxicant Concentration Exceeding LC50 | | Number Samples With Toxicant Concentration Exceeding LC50 and Sample was Lethal | | Comments |
|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Mn | 2.9 | 0 | 0 | - | - | Concentrations exceeding 1/10th the LC50 occurred in all samples from STP (highest levels measured of all STPs); summer samples from that STP contained highest levels (up to 1 mg/L), but were all non-lethal |
| Mo | 0.79 | 0 | 0 | - | - | Highest concentration measured was 0.35 mg/L in a sample which was non-lethal |
| $NH_3$-N (un-ionized) | 0.45 | 40 | NA[c] | 34 | - | See Figure 4.32, text |
| Ni | 32 | 0 | 0 | - | - | Most effluents contained Ni concentrations 1 to 2 orders magnitude below LC50 |
| $NO_2$-N | 0.30 | 73 | NA | 33 | - | |
| Sulphide | 0.013 | 14 | NA | 14 | - | All occurrences during winter |
| Se | 9 | 0 | 0 | - | - | Se was frequently non-detectable and was not found at concentrations greater than 2 orders of magnitude below LC50 |
| Sr | 0.23 | 54 | 51 | 30 | 28 | 7 of 11 samples containing Sr concentrations exceeding 2.0 mg/L were non-lethal |
| TRC | 0.06 | 49 | NA | 36 | - | See Figure 4.33, text |

[a] Only samples with low TRC considered.
[b] Appendix D.
[c] Not analyzed.
[d] MDL - method detection limit.

**Figure 4.37 Toxicity of STP Effluents to Rainbow Trout as a Function of Initial TRC Concentrations**



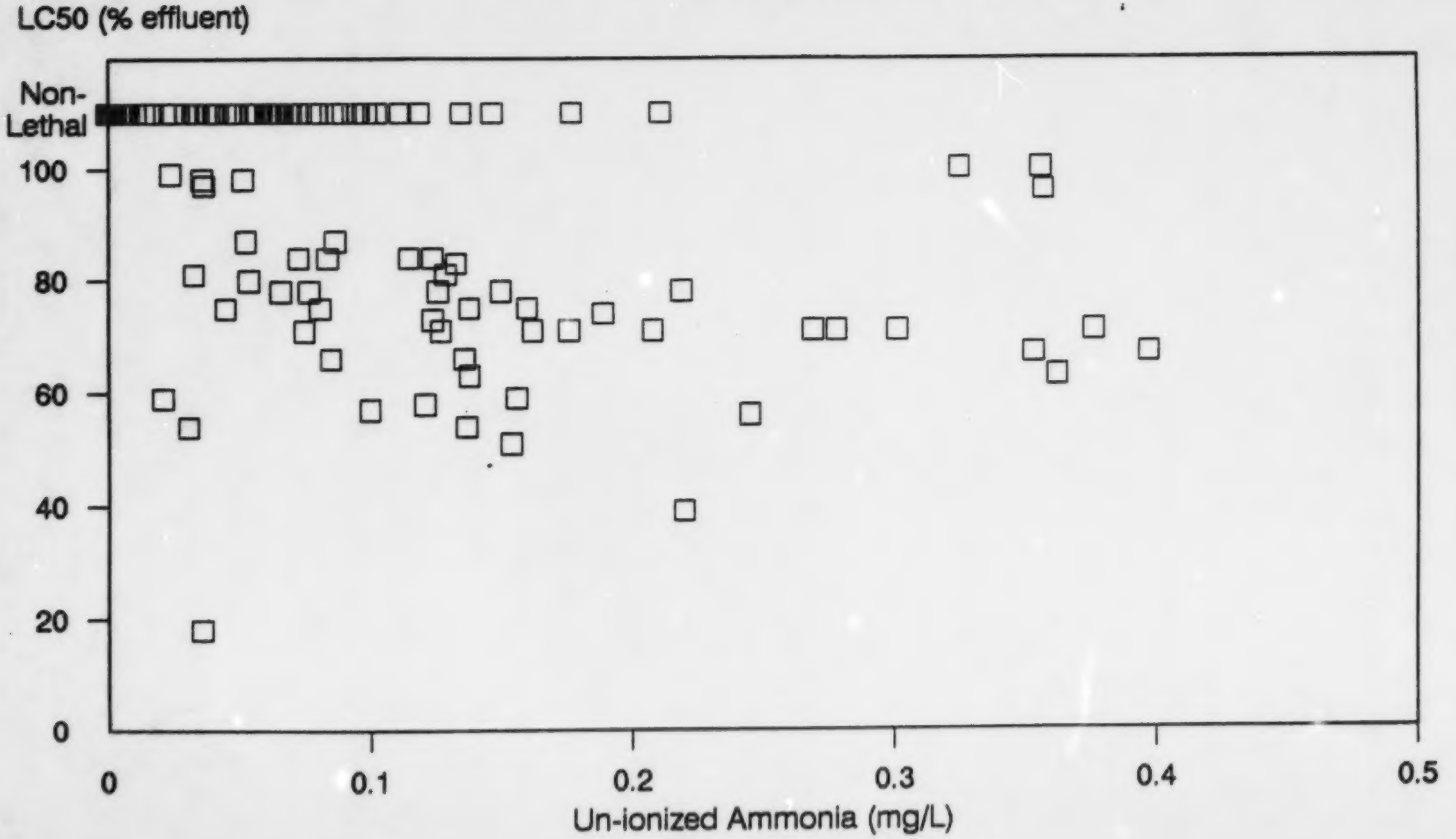
ammonia exceeded the reported LC50, 34 were lethal to trout. A plot of un-ionized ammonia concentration versus LC50 suggests that concentrations above about 0.1 mg/L are usually lethal to trout (Figure 4.38). Higher concentrations, however, did not necessarily result in greater toxicity. Changes in both total ammonia concentrations and pH levels during the tests (Section 4.2.2) presumably caused un-ionized ammonia concentrations to change relative to initial levels, thereby reducing the sensitivity of statistical analysis of the relationship between un-ionized ammonia and rainbow trout lethality.

Un-ionized ammonia concentrations for summer and winter samples were statistically compared. Although the data indicated a trend toward higher un-ionized ammonia in winter, this was not significant at the 95% confidence level. Considering that mean values for summer and winter were significantly different at the 90% confidence level, and the uncertainty associated with the use of initial un-ionized ammonia concentrations (above), it is possible that the difference in un-ionized ammonia levels between summer and winter accounted, at least in part, for seasonal differences in toxicity to rainbow trout.

This conclusion was further supported by examining results of the four plants that demonstrated markedly greater toxicity in winter compared to summer samples (Section 3.1.1). Mean winter un-ionized ammonia concentrations for three of the STPs (Highland Creek, Lindsay and Wallaceburg) were more than two times higher than for summer samples. Winter samples from those plants usually exceeded the 0.1 mg/L level above which rainbow trout lethality may be expected. Effluent samples from the fourth plant, Perth, did not exceed 0.1 mg/L un-ionized ammonia in either season, but did show high sulphide levels in winter (mean 6.6 mg/L) relative to summer (less than 0.05 mg/L); sulphide concentrations of approximately 0.013 mg/L are lethal to trout (Appendix Table D.1).

Also, the only other STPs which produced effluents that frequently contained un-ionized ammonia concentrations of more than 0.1 mg/L were Stratford and Midland. These levels occurred during summer, however, and effluent samples from these two plants caused more lethality in summer than in winter (Tables 3.1, 3.2).

## Figure 4.38 Toxicity of STP Effluents to Rainbow Trout as a Function of Initial Un-ionized Ammonia Concentrations



DOC and BOD levels also accounted for some toxicity test variability. However, since each parameter is non-specific (i.e., they may reflect the presence of many different types of chemicals), LC50 values were not available in the literature for DOC and BOD. Both parameters were negatively correlated against LC50, suggesting the presence of toxic organic materials. Since the organic chemicals measured in this study were rarely detected (Sections 3.3 and 4.4.7), the identity of the toxic organic chemicals is not known. It is also possible that the correlations between these parameters and effluent toxicity did not indicate a dose-effect relationship, but, instead, indicated co-variance with the actual effluent toxicants.

The increased frequency of elevated lethality in samples containing elevated aluminum or copper suggested that those parameters may have been at least partially responsible for effluent toxicity (Table 4.5). Evaluation of data for the other inividual parameters (Ag, As, Cd, Co, Hg, Mn, Mo, $NO_2$, Se, and Sr) did not suggest any conclusive relationships to STP effluent toxicity. Although toxicity may have occurred through additive or synergistic chemical interactions (Marking 1985), it was beyond the scope of this study to examine such complex phenomena.

#### 4.4.3.3 Summary

The data suggest that TRC and un-ionized ammonia concentrations were the most influential toxicants to rainbow trout in samples collected from ten Ontario STPs. Elevated sulphide levels associated with lagoon STPs were toxic to trout. Although other parameters were all implicated as possible toxicants, there was insufficient evidence to support their role with any confidence (Al and Cu possibly excepted). Variations in the concentrations of these parameters only accounted for approximately one-half of the variability in toxicity test results, suggesting that either the chemical parameters measured at the beginning of the test do not accurately reflect exposure concentrations during the test, that interactions between toxicants affected toxicity, or that other contaminants contributed to toxicity.

### 4.4.4 *Daphnia magna*

#### 4.4.4.1 Regression Analyses

STP effluent TRC concentrations were consistently associated with 33 to 70% of the variability in toxicity of samples tested as received to *D. magna* (Table 4.6).

When only samples with low TRC were considered in regression analysis, aluminum, arsenic, BOD, calcium, DOC, magnesium, manganese and molybdenum were all associated with sample toxicity to *D. magna.* Measured concentrations of these parameters could explain only 12 to 35% of the variability in toxicity test data. Positive correlations with LC50s were associated with calcium, magnesium and BOD concentrations. DOC levels were also positively correlated with LC50s, except in the cases of data sets 7,8 and 11 (low TRC samples), in each of which only 11 to 13 samples were evaluated.

#### 4.4.4.2 Parameter-Specific Evaluation

Concentrations of TRC above approximately 0.2 mg/L were typically lethal (Figure 4.39). This is an order of magnitude greater than the mean acutely lethal concentration of 0.03 mg/L reported for *D. magna* by the U.S. EPA (1985b) (Table 4.7), but may be due to rapid dissipation of TRC from test solutions (static) in this study, relative to continuous-flow conditions reported by the EPA.

The toxicity associated with effluent constituents other than TRC was examined by evaluating the data for samples containing low TRC ( 0.1 mg/L).

In contrast to rainbow trout tests, un-ionized ammonia concentrations did not appear to be a major factor in *D. magna* tests (Figure 4.40).

STP effluent toxicity to *D. magna* could not be conclusively attributed to any of the other parameters examined (Table 4.7), but this was probably due, in part, to the fact that few samples (18) containing low TRC were lethal. Positive correlations between LC50s and calcium, magnesium, BOD and/or DOC concentrations suggest that those substances had an ameliorating effect on toxicity, since toxicity tended to decrease as

TABLE 4.6c MULTIPLE REGRESSION ANALYSIS[a] OF STP EFFLUENT CHEMISTRY VERSUS ACUTE TOXICITY TO DAPHNIA MAGNA

| Data Set Number | Data Set Data Included[b] | No. of Samples Considered | First Parameter | $R^2$ | Second Parameter | $R^2$ | Third Parameter | $R^2$ | Fourth Parameter | $R^2$ | Fifth Parameter | $R^2$ | Sixth Parameter | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **As-Received** | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 121 | TRC | 0.54 | Ni | 0.56 | DOC | 0.57 | | | | | | |
| 2 | L and N, S and W, F | 119 | TRC | 0.54 | Cu | 0.55 | Mn | 0.57 | | | | | | |
| 3 | L and N, S, M | 60 | TRC | 0.48 | | | | | | | | | | |
| 4 | L and N, S, F | 59 | TRC | 0.48 | Ni | 0.51 | | | | | | | | |
| 5 | L and N, W, M | 61 | TRC | 0.60 | Fe | 0.67 | | | | | | | | |
| 6 | L and N, W, F | 61 | TRC | 0.60 | Cu | 0.65 | | | | | | | | |
| 7 | L, S and W, M | 33 | TRC | 0.36 | Al | 0.41 | | | | | | | | |
| 8 | L, S and W, F | 32 | TRC | 0.33 | Se | 0.44 | Al | 0.50 | Fe | 0.55 | Mn | 0.61 | | |
| 9 | L, S, F | 21 | TRC | 0.34 | As | 0.50 | | | | | | | | |
| 10 | L, W, F | 11 | TRC | 0.70 | Al | 0.80 | | | | | | | | |
| 11 | L, S, M | 22 | TRC | 0.33 | | | | | | | | | | |
| 12 | L, W, M | 11 | TRC | 0.70 | Mo | 0.80 | | | | | | | | |
| **Low TRC Samples Only** | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 122 | Mg | 0.07 | Ca | 0.12 | | | | | | | | |
| 2 | L and N, S and W, F | 121 | Ca | 0.08 | Mn | 0.14 | | | | | | | | |
| 3 | L and N, S, M | 60 | Al | 0.15 | Mg | 0.20 | Hg | 0.34 | | | | | | |
| 4 | L and N, S, F | 59 | Mg | 0.08 | Ca | 0.15 | As | 0.20 | | | | | | |
| 5 | L and N, W, M | 61 | Ca | 0.08 | BOD | 0.13 | | | | | | | | |
| 6 | L and N, W, F | 61 | Ca | 0.08 | BOD | 0.14 | | | | | | | | |
| 7 | L, S and W, M | 13 | DOC | 0.27 | | | | | | | | | | |
| 8 | L, S and W, F | 13 | DOC | 0.27 | | | | | | | | | | |
| 9 | L, S, F | 11 | Mo | 0.35 | | | | | | | | | | |
| 10 | L, W, F | 2 | No regression | | | | | | | | | | | |
| 11 | L, S, M | 11 | DOC | 0.30 | | | | | | | | | | |
| 12 | L, W, M | 2 | No regression | | | | | | | | | | | |

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[a] Each $R^2$ reflects the degree to which variability toxicity data are explained by variability in concentration of all the chemical parameters included in the regression to that point.

[b] L - lethal, N - non-lethal, S - summer, W - winter, M - total metal concentrations, F - filtered metal concentrations.

[c] $NH_3$ expressed as un-ionized; estimated from temperature, pH and total ammonia levels measured at initiation of the test.

[d] No correlations were significant at 95% confidence level.

Figure 4.39 Toxicity of STP Effluents to *Daphnia magna* as a Function of Initial TRC Concentrations

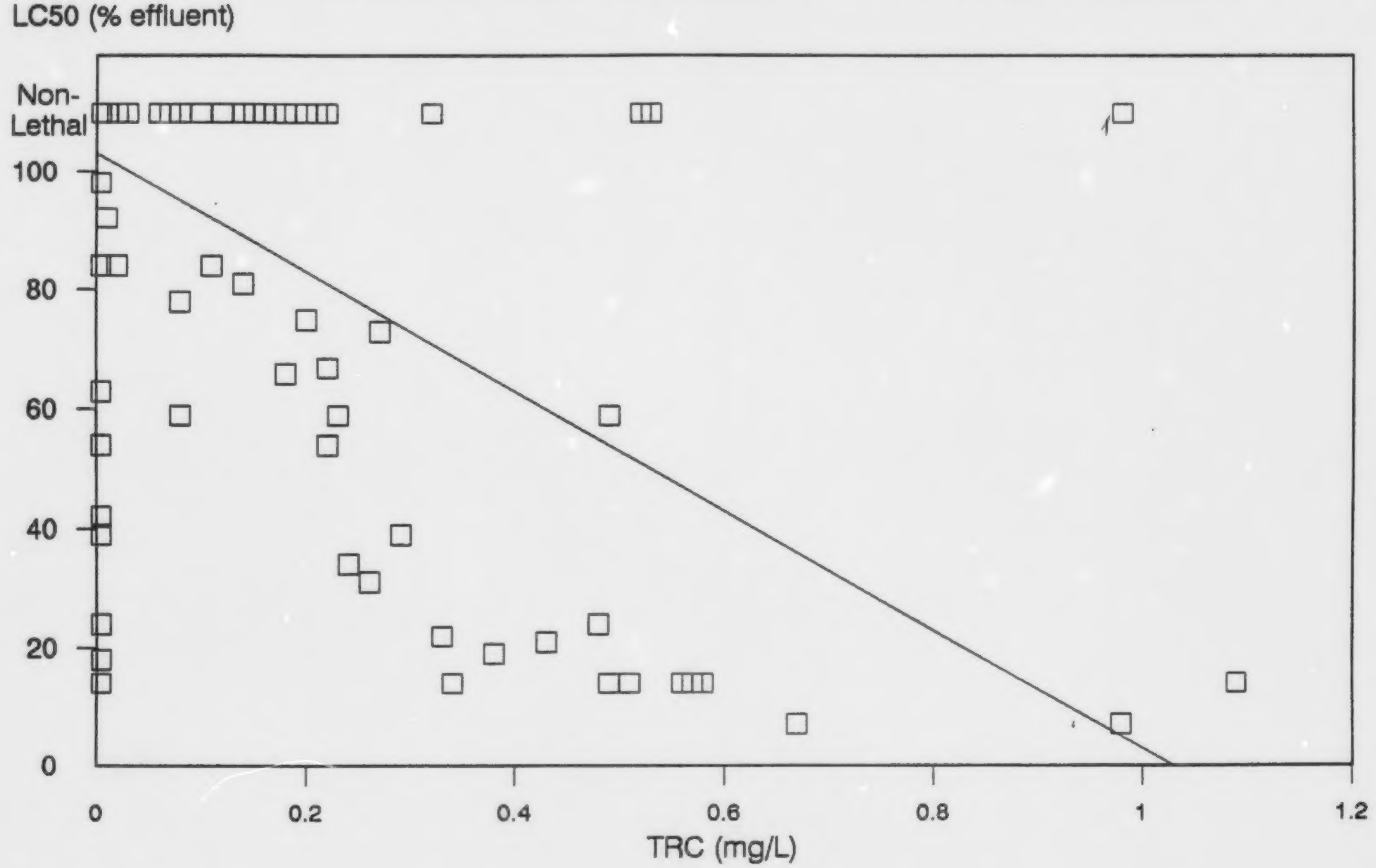


TABLE 4.7: COMPARISON OF STP EFFLUENT CHEMISTRY[a] TO CONCENTRATIONS REPORTED AS LETHAL TO DAPHNIA MAGNA

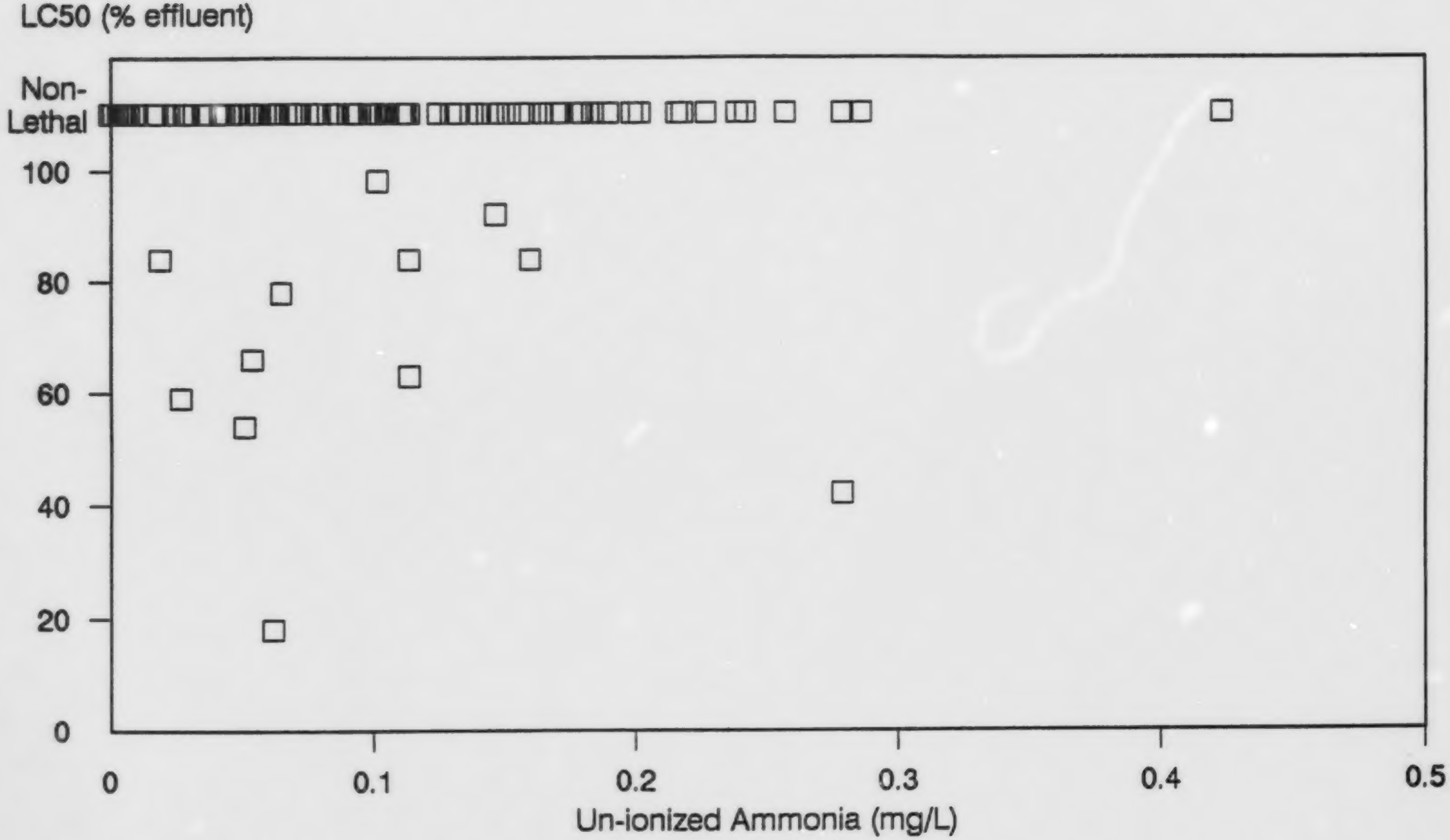
| Parameter | Approximate LC50 (mg/L)[b] | Number Samples with Toxicant Concentration Exceeding LC50 | | Number Samples with Toxicant Concentration Exceeding LC50 and Sample was Lethal | | Comments |
|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Al | 3.3 | 0 | 0 | - | - | 8 samples with total Al exceeding 1 mg/L were all non-lethal, but filtered Al in same samples was typically less by one order magnitude |
| As | 5.3 | 0 | 0 | - | - | Most samples did not contain detectable As; all detectable concentrations were 2 orders magnitude below LC50 |
| Co | 0.010 | 9 | 13 | 0 | 1 | |
| Cu | 0.060 | 16 | 16 | 5 | 7 | Total Cu was less than filtered Cu in 5 of 16 samples containing filtered Cu exceeding the LC50 (both lethal and non-lethal samples); therefore, chemical values are questionable |
| Cr | 0.023 | 6 | 3 | 1 | 1 | Total Cr was less than filtered Cr in all cases where filtered Cr exceeded LC50; in most other samples, filtered Cr was an order of magnitude less than non-filtered Cr |
| Fe | 5.9 | 1 | 0 | 0 | - | |
| Mn | no estimate | | | | | |
| Mo | no estimate | | | | | |
| $NH_3$-N (un-ionized) | 1.6 | 0 | NA[c] | - | - | See Figure 4.35 |
| Ni | 3.3 | 0 | 0 | - | - | Only 4 of 15 samples containing the highest Ni levels (greater than 0.1 mg/L) were lethal. Sample with highest Ni concentration (0.63 mg/L) was non-lethal |
| TRC | 0.03 | 52 | NA | 30 | - | See Figure 4.34 |

[a] Only samples with low TRC evaluated.

[b] Appendix D.

[c] NA - not analyzed.

**Figure 4.40 Toxicity of STP Effluents to Daphnia magna as a Function of Initial Un-ionized Ammonia Concentrations**



their concentrations increased. Calcium and magnesium and some organic chemicals are known to reduce the toxicity of other aqueous contaminants, particularly metals (Sprague, 1985). However, no single metal measured in this study could be attributed with observed toxicity. Again, evaluation of possible additive or interactive effects among toxicants was beyond the scope of this study.

#### 4.4.4.3 Summary

Residual chlorine was the only parameter measured in this study that could be associated with effluent sample toxicity to D. magna. Only 18 samples containing low chlorine levels were lethal. The positive relationship between LC50 and calcium, magnesium, BOD, and/or DOC suggests that some toxicity may have occured as a results of the presence of metals, but no individual metal measured in this study could be attributed with the observed toxicity.

### 4.4.5 Fathead Minnow

#### 4.4.5.1 Regression Analyses

As observed with rainbow trout, un-ionized ammonia appeared to be an important parameter in multiple regression analyses of fathead minnow toxicity against effluent chemistry. Again, it should be noted that samples were adjusted to pH 6.0 prior to test initiation if acute lethal effects due to ammonia were anticipated. Consequently, it is not surprising that the relationship between un-ionized ammonia levels and fathead minnow toxicity applied most strongly to effects on growth compared to chronic lethality (Table 4.8).

Of the other chemical parameters measured in each sample, none were consistently associated with chronic fathead minnow lethality (Table 4.8), but this may be largely a result of the low incidence of lethality among samples. Consistent with the results for rainbow trout tests, BOD and DOC were negatively correlated with LC50s, except in two data sets (3 and 4) pertaining to summer samples only, in which DOC was positively correlated.

TABLE 4.8: MULTIPLE REGRESSION ANALYSIS[a] OF STP EFFLUENT CHEMISTRY VERSUS CHRONIC TOXICITY TO FATHEAD MINNOWS - LOW TRC SAMPLES ONLY

| Number | Data Set<br>Data Included[b] | No. of Samples Considered | First Parameter | $R^2$ | Second Parameter | $R^2$ | Third Parameter | $R^2$ | Fourth Parameter | $R^2$ | Fifth Parameter | $R^2$ | Sixth Parameter | $R^2$ | Seventh Parameter | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sublethality (Growth)** | | | | | | | | | | | | | | | | |
| 1 | T and X, S and W, M | 79 | $NH_3$[c] | 0.31 | $NO_2$ | 0.35 | | | | | | | | | | |
| 2 | T and X, S and W, F | 79 | $NH_3$ | 0.31 | As | 0.36 | Mn | 0.40 | BOD | 0.44 | | | | | | |
| 3 | T and X, S, M | 40 | $NH_3$ | 0.37 | $NO_2$ | 0.53 | | | | | | | | | | |
| 4 | T and X, S, F | 40 | $NH_3$ | 0.37 | $NO_2$ | 0.53 | Fe | 0.64 | | | | | | | | |
| 5 | T and X, W, M | 39 | $NH_3$ | 0.25 | Se | 0.31 | | | | | | | | | | |
| 6 | T and X, W, F | 39 | $NH_3$ | 0.25 | As | 0.42 | | | | | | | | | | |
| 7 | T, S and W, M | 55 | No regression[d] | | | | | | | | | | | | | |
| 8 | T, S and W, F | 54 | Cr | 0.07 | | | | | | | | | | | | |
| 9 | T, S, F | 26 | Cr | 0.29 | VSS | 0.42 | | | | | | | | | | |
| 10 | T, W, F | 28 | No regression | | | | | | | | | | | | | |
| **Lethality** | | | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 79 | $NH_3$[c] | 0.19 | Pb | 0.33 | Mo | 0.37 | Zn | 0.41 | Al | 0.43 | Mg | 0.47 | | |
| 2 | L and N, S and W, F | 79 | $NH_3$ | 0.19 | BOD | 0.23 | | | | | | | | | | |
| 3 | L and N, S, M | 40 | VSS | 0.15 | BOD | 0.36 | DOC | 0.44 | $NH_3$ | 0.50 | Ca | 0.57 | Co | 0.61 | Ni | 0.66 |
| 4 | L and N, S, F | 40 | Ca | 0.16 | $NO_2$ | 0.28 | DOC | 0.45 | $NH_3$ | 0.52 | Sr | 0.58 | | | | |
| 5 | L and N, W, M | 39 | Pb | 0.64 | Cr | 0.70 | $NH_3$ | 0.77 | Mg | 0.83 | | | | | | |
| 6 | L and N, W, F | 39 | Cr | 0.36 | $NH_3$ | 0.53 | Zn | 0.60 | DOC | 0.67 | | | | | | |
| 7 | L, S and W, M | 15 | Mn | 0.27 | | | | | | | | | | | | |
| 8 | L, S and W, F | 14 | Cr | 0.62 | | | | | | | | | | | | |
| 9 | L, S, F | 5 | Cu | 0.72 | | | | | | | | | | | | |
| 10 | L, W, F | 9 | As | 0.63 | | | | | | | | | | | | |

[a] Each $R^2$ reflects the degree to which variability toxicity data are explained by variability in concentration of all the chemical parameters included in the regression to that point.

[b] L - lethal, N - non-lethal, T - toxic, X - non-toxic, S - summer, W - winter, M - total metal concentrations, F - filtered metal concentrations.

[c] $NH_3$ expressed as un-ionized; estimated from temperature, pH and total ammonia levels measured at initiation of the test.

[d] No correlations were significant at 95% confidence levels.

In addition to un-ionized ammonia, nitrite and several other effluent constituents (arsenic, mangenese, iron, selenium and chromium) were identified as toxicants potentially associated with growth effects on fathead minnow larvae. The concentrations of those measured contaminants typically explained 30 to 65% of the variability in sublethal toxicity data.

### 4.4.5.2 Parameter-Specific Evaluation

The effect of effluent TRC on toxicity of fathead minnows could not be evaluated since chronic toxicity tests were conducted only on samples with low TRC concentrations.

A dose-response relationship between un-ionized ammonia concentrations versus fathead minnow chronic value or LC50 for each effluent sample was not evident (Figure 4.41). As discussed in Section 4.3, however, un-ionized ammonia concentrations changed by up to a factor of two times the original value in the majority of samples (and more in others) by the end of the 7-day tests. This presumably decreased the sensitivity of analyses based on initial un-ionized ammonia levels.

Of the chemicals associated with chronic fathead minnow lethality in regression analysis (Table 4.8), none could be conclusively attributed with causing lethality (Table 4.9). As discussed previously, there were few lethal samples on which to base such an evaluation. The apparent toxic effects of substances measured as BOD and DOC could not be further evaluated due to their non-specific nature. It is possible that those non-specific parameters simply demonstrate co-variance with effluent toxicants.

The data for arsenic, lead, molybdenum, selenium, and silver suggested no relationship to effluent sample toxicity. Effluent concentrations of aluminum, copper, nickel, and zinc also did not appear to be related to lethality, although they may have been associated with sublethal effects. Growth effects among minnows may also have been a result of exposure to chromium, iron, manganese and/or nitrite.

Sulphide concentrations were not included in regression analyses since data were available for only the two lagoon STPs (Lindsay, Perth). All samples which contained detectable sulphide concentrations impaired the growth of fathead minnow larvae.

## Figure 4.41 Toxicity of STP Effluents to Fathead Minnow as a Function of Un-ionized Ammonia Concentrations

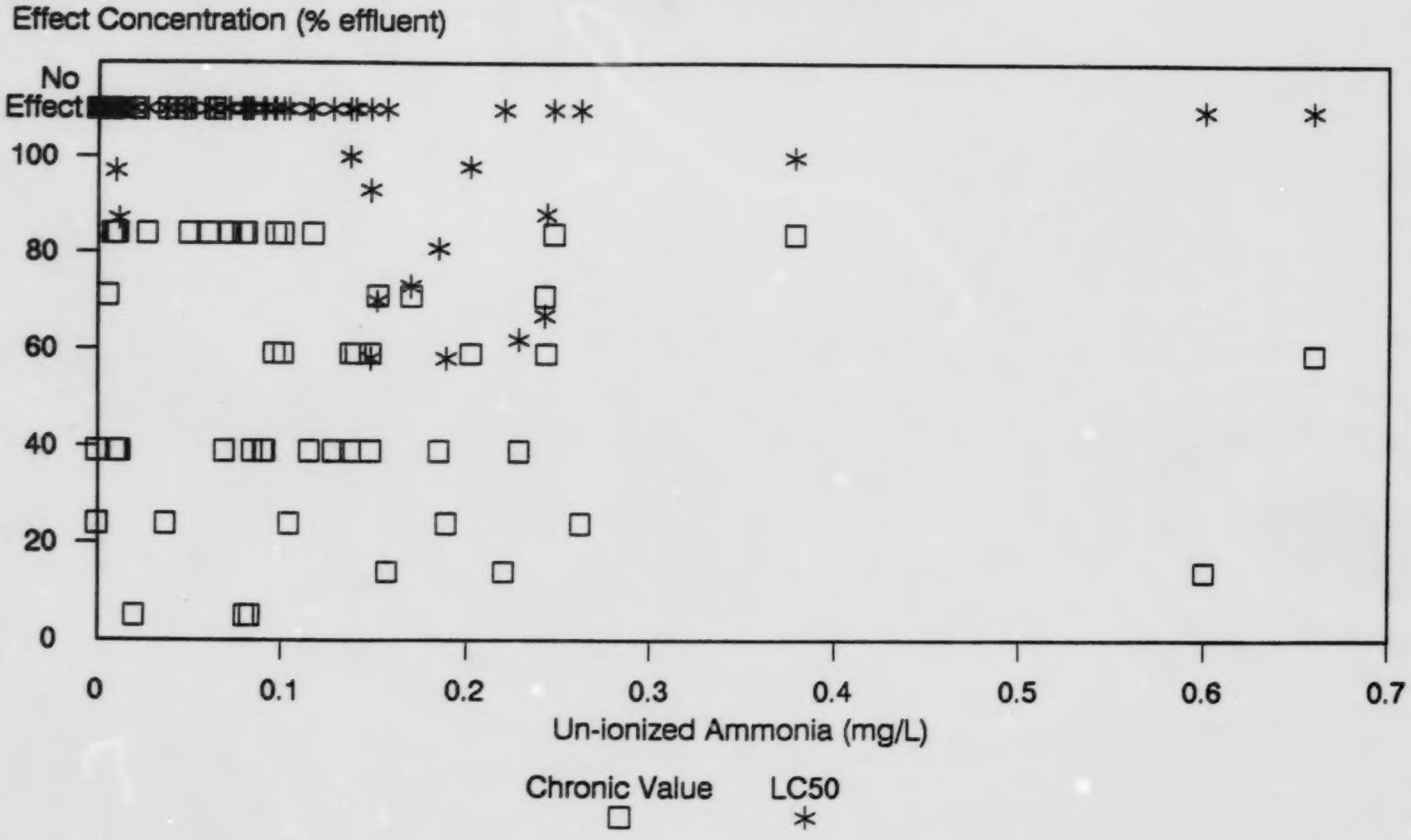


TABLE 4.9: COMPARISON OF STP EFFLUENT CHEMISTRY TO CONCENTRATIONS REPORTED TO BE CHRONICALLY TOXIC TO FATHEAD MINNOWS

| Parameter | Estimated Chronic Concentration (mg/L) | Number of Samples With Toxicant Concentration Exceeding Chronic Estimate | | Number of Samples With Toxicant Concentration Exceeding Chronic Estimate and Sample Was Lethal | | Number of Samples With Toxicant Concentration Exceeding Chronic Estimate and Sample Was Sublethal | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Ag | 0.0010 | 0 | 0 | - | - | - | - | MDL was 3 orders of magnitude greater than chronic estimate |
| Al | 0.50 | 19 | 0 | 3 | 0 | 16 | 0 | 23 of 30 samples containing filtered Al greater than 0.10 mg/L resulted in growth impairment |
| As | 1.3 | | | - | - | - | - | Samples with detectable levels had concentrations that were more than an order of magnitude below chronic estimate |
| Cr | 6.9 | 0 | 0 | - | - | - | - | 14 of 16 samples with filtered Cr above 0.006 mg/L resulted in growth impairment |
| Cu | 0.020 | 29 | 28 | 4 | 4 | 18 | 17 | |
| Fe | 1.5 | 12 | 0 | 3 | - | 9 | - | |
| Mn | 1.5 | 0 | 0 | - | - | - | - | 8 of 8 samples containing both total and filtered Mn of more than 0.30 mg/L resulted in growth impairment, but the four containing the highest concentrations (greater than 0.6 mg/L) were not lethal |
| Mo | 0.38 | 0 | 0 | - | - | - | - | Mo in samples was usually at least one order of magnitude below chronic estimate; highest concentration (0.25 mg/L) was associated with sample causing no lethal or sublethal effect |
| $NO_2$-N | 5 | 1 | NA[b] | 1 | - | 1 | - | 17 of 21 samples containing more than 1 mg/L nitrite were sublethally toxic but only 6 of 21 were lethal |
| $NH_3$-N | 0.13 | 22 | NA | 11 | - | .0 | 22 | -See Figure 4.36 |

TABLE 4.9: COMPARISON OF STP EFFLUENT CHEMISTRY TO CONCENTRATIONS REPORTED TO BE CHRONICALLY TOXIC TO FATHEAD MINNOWS
(cont'd)

| Parameter | Estimated Chronic Concentration (mg/L) | Number of Samples With Toxicant Concentration Exceeding Chronic Estimate | | Number of Samples With Toxicant Concentration Exceeding Chronic Estimat and Sample Was Lethal | | Number of Samples With Toxicant Concentration Exceeding Chronic Estimate and Sample Was Sublethal | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Ni | 0.38 | 8 | 7 | 2 | 2 | 7 | 6 | 7 of 8 samples containing total Ni concentrations of more than 0.10 mg/L were sublethally toxic, but only two were lethal; 6 of 7 samples with filtered Ni above 0.10 mg/L were sublethally toxic |
| Pb | 6 | 0 | 0 | - | - | - | - | All samples contained Pb at concentrations more than an order of magnitude below chronic estimate |
| Se | 0.11 | 0 | 0 | - | - | - | - | Most samples contained Se at concentrations more than one order of magnitude less than chronic estimate |
| Sr | No estimate | | | | | | | |
| Sulphide | 0.005 | 7 | NA | 3 | - | 7 | - | All occurrences associated with winter samples |
| Zn | 0.11 | 1 | 4 | 0 | 2 | 1 | 3 | |

[a] Chronic toxicly estimates were typically derived from very limited data and could not be considered sufficiently precise that separate estimates for lethality and sublethality could be developed.

[b] NA - not analyzed.

### 4.4.5.3 Summary

Due to the small number of lethal samples, the toxicants associated with chronic lethality to minnow could not be conclusively evaluated. As observed in rainbow trout tests, organic materials measured as BOD and DOC may have contributed to fathead minnow lethality or may simply co-vary with effluent toxicants. Elevated un-ionized ammonia concentrations were associated with toxicity of STP effluents to fathead minnows. The presence of sulphide in lagoon STP effluents was likely responsible for some degree of growth impairment observed in toxicity tests of those effluents. Various other STP effluent contaminants (Al, Cr, Cu, Fe, Mn, Ni, $NO_2$, Zn) may have also contributed to growth impairment of minnow larvae.

## 4.4.6 Ceriodaphnia dubia

### 4.4.6.1 Regression Analyses

Effluent sample concentrations of metals (nickel, cobalt, strontium), un-ionized ammonia, DOC, BOD, and total suspended solids explained only 15 to 30% of the variability in chronic C. dubia lethality (Table 4.10). Many of the same parameters (BOD, dissoved organic carbon, un-ionized ammonia, cobalt, nickel, strontium) and several others (aluminum, nitrate, manganese, lead, zinc) were identified as potential sublethal toxicants.

BOD and total suspended solids were negatively correlated, and dissolved organic carbon was positively correlated, with C. dubia LC50 and Ch.V.

### 4.4.6.2 Parameter-Specific Evaluation

The effect of effluent TRC on toxicity of C. dubia could not be evaluated since chronic toxicity tests were conducted only on samples with low TRC concentrations. While only one sample contained un-ionized ammonia concentrations which exceeded the estimated chronic value of 0.3 mg/L, 21 of 28 samples containing concentrations of more than 0.1 mg/L caused reproductive impairment of C. dubia (Table 4.11). Figure 4.42 indicates an apparent lack of dose-response relationship between initial un-ionized ammonia concentrations in effluent samples and corresponding C. dubia toxicity. As discussed in

TABLE 4.10: MULTIPLE REGRESSION ANALYSIS[a] OF STP EFFLUENT CHEMISTRY VERSUS CHRONIC TOXICITY TO *CERIODAPHNIA DUBIA* - LOW TRC SAMPLES ONLY

| Number | Data Set<br>Data Included[b] | No. of Samples Considered | First Parameter | $R^2$ | Second Parameter | $R^2$ | Third Parameter | $R^2$ | Fourth Parameter | $R^2$ | Fifth Parameter | $R^2$ | Sixth Parameter | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sublethality (Reproduction)** | | | | | | | | | | | | | | |
| 1 | T and X, S and W, M | 79 | BOD | 0.16 | DOC | 0.25 | Al | 0.33 | Sr | 0.41 | $NH_3$[c] | 0.43 | $NO_3$ | 0.52 |
| 2 | T and X, S and W, F | 79 | BOD | 0.16 | DOC | 0.28 | Al | 0.31 | | | | | | |
| 3 | T and X, S, M | 40 | Zn | 0.33 | BOD | 0.40 | | | | | | | | |
| 4 | T and X, S, F | 40 | Ni | 0.25 | BOD | 0.34 | DOC | 0.44 | Mn | 0.51 | | | | |
| 5 | T and X, W, M | 39 | Sr | 0.12 | DOC | 0.20 | | | | | | | | |
| 6 | T and X, W, F | 39 | Co | 0.15 | Sr | 0.27 | Mg | 0.33 | | | | | | |
| 7 | T, S and W, M | 45 | No regression[d] | | | | | | | | | | | |
| 8 | T, S and W, F | 44 | No regression | | | | | | | | | | | |
| 9 | T, S, F | 15 | $NH_3$ | 0.35 | Zn | 0.61 | Pb | 0.71 | | | | | | |
| 10 | T, W, F | 29 | No regression | | | | | | | | | | | |
| **Lethality** | | | | | | | | | | | | | | |
| 1 | L and N, S and W, M | 78 | Ni | 0.09 | DOC | 0.13 | BOD | 0.22 | | | | | | |
| 2 | L and N, S and W, F | 78 | Ni | 0.12 | DOC | 0.15 | BOD | 0.23 | | | | | | |
| 3 | L and N, S, M | 39 | Zn | 0.28 | | | | | | | | | | |
| 4 | L and N, S, F | 39 | Ni | 0.20 | TSS | 0.27 | | | | | | | | |
| 5 | L and N, W, M | 39 | DOC | 0.10 | $NH_3$ | 0.25 | | | | | | | | |
| 6 | L and N, W, F | 39 | Co | 0.17 | | | | | | | | | | |
| 7 | L, S and W, M | 24 | $NH_3$ | 0.15 | Sr | 0.30 | | | | | | | | |
| 8 | L, S and W, F | 23 | $NH_3$ | 0.15 | | | | | | | | | | |
| 9 | L, S, F | 9 | No regression | | | | | | | | | | | |
| 10 | L, W, F | 14 | Sr | 0.32 | | | | | | | | | | |

[a] Each $R^2$ reflects the degree to which variability toxicity data are explained by variability in concentration of all the chemical parameters included in the regression to that point.

[b] L - lethal, N - non-lethal, T - toxic, X - non-toxic, S - summer, W - winter, M - total metal concentrations, F - filtered metal concentrations.

[c] $NH_3$ expressed as un-ionized; estimated from temperature, pH and total ammonia levels measured at initiation of the test.

[d] No correlations were significant at 95% confidence level.

**TABLE 4.11: COMPARISON OF EFFLUENT CHEMISTRY TO CONCENTRATIONS REPORTED TO BE CHRONICALLY TOXIC TO *CERIODAPHNIA DUBIA***

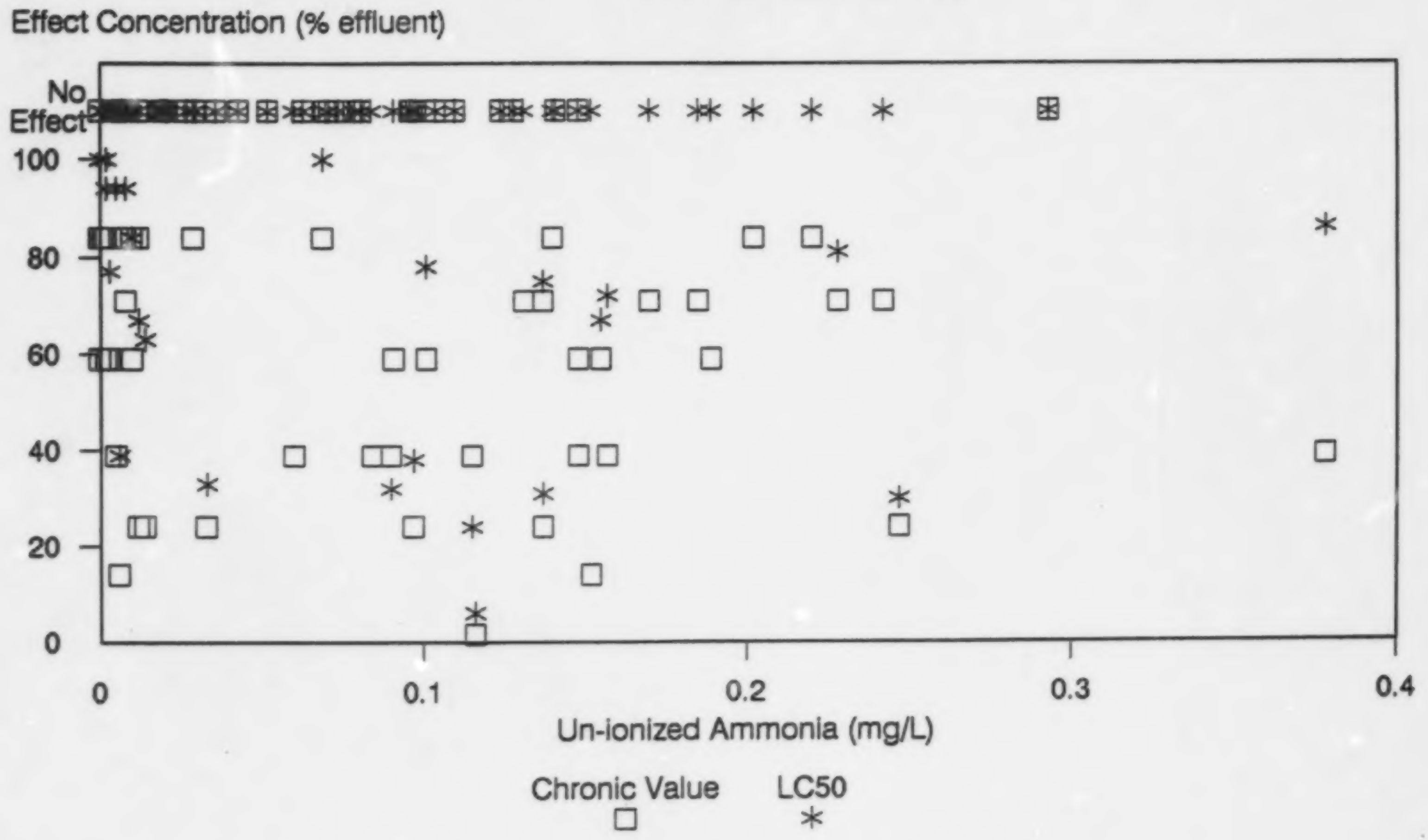
| Parameter | Estimated Chronic Concentration[a] (mg/L) | No. of Samples with Toxicant Concentration Exceeding Chronic Estimate | | No. of Samples with Toxicant Concentration Exceeding Chronic Estimate and Sample was Lethal | | No. of Samples with Toxicant Concentration Exceeding Chronic Estimate and Sample was Sublethal | | Comment |
|---|---|---|---|---|---|---|---|---|
| | | Non-Filtered | Filtered | Non-Filtered | Filtered | Non-Filtered | Filtered | |
| Al | 0.33 | 23 | 2 | 6 | 2 | 13 | 2 | |
| Co | 0.005 | 9 | 16 | 4 | 9 | 5 | 11 | Many filtered Co concentrations exceeded total Co |
| Cr | 0.040 | 3 | 2 | 1 | 0 | 2 | 2 | |
| Cu | 0.006 | 54 | 64 | 21 | 19 | 36 | 31 | 8 of 11 samples containing filtered Cu greater than 0.01 mg/L were not lethally or sublethally toxic; filtered versus non-filtered concentrations were questionable in several cases |
| Fe | 0.6 | 24 | 1 | 7 | 1 | 14 | 1 | |
| Mn | No estimate | | | | | | | Of 8 samples containing both filtered and total Mn at concentrations greater than 0.3 mg/L, 5 were lethal and 8 were sublethal |
| $NH_3$-N[c] | 0.30 | 1 | NA[b] | 1 | - | 1 | - | 21 of 28 samples with un-ionized $NH_3$ greater than 0.10 showed sublethal toxicity; see Figure 4.37 |
| Ni | 0.33 | 0 | 0 | - | - | - | - | 5 of 8 samples containing filtered Ni at concentrations approaching chronic estimate (greater than 0.1 mg/L) were sublethally toxic |
| $NO_3$-N | No estimate | | | | | | | 13 of 20 samples $NO_3$-N concentrations of more ;than 10 mg/L were sublethally toxic but only 9 of 20 were lethal |
| Pb | 0.045 | 0 | 2 | - | 1 | - | 1 | In both samples, filtered Pb exceeds total Pb |
| Sr | 21 | 0 | 0 | - | - | - | - | 16 of 16 samples containing both filtered and non-filtered concentrations greater than 4 mg/L were sublethally toxic and 9 were lethal |
| Zn | 0.034 | 23 | 24 | 11 | 11 | 18 | 17 | |

[a] Appendix D.

[b] NA - not analyzed.

[c] Un-ionized.

## Figure 4.42 Toxicity of STP Effluents to C. dubia as a Function of Un-ionized Ammonia Concentrations



Section 4.2.2, this may be due, in part, to the uncertainty associated with evaluating the toxic contribution of un-ionized ammonia based on initial concentrations, since un-ionized ammonia levels did not remain stable throughout the tests.

While chronic lethal and sublethal toxicity to C. dubia could not be conclusively associated with any specific effluent parameter(s), reproductive impairment may have been related to aluminum, chromium, cobalt, copper, lead, nickel, strontium, and/or zinc exposure. With respect to most metals (eg., Al, Co, Cr, Cu, Fe, Sr, Zn), filtered metal concentrations may provide more meaningful estimation of potentially toxic concentrations.

As observed in tests with rainbow trout, D. magna (except two data sets for winter) and fathead minnows, organic substances measured as BOD were associated with increased toxicity (lower LC50 or Ch.V.) of effluents to C. dubia. Consistent with D. magna tests, but in contrast to rainbow trout and fathead minnow tests, elevated concentrations of substances measured as DOC were generally associated with less toxicity (higher LC50 or Ch.V.) in C. dubia tests. Whether these trends indicated cause-effect relationships or simply co-variance with effluent toxicants is not known.

As discussed previously, the potential additive or interactive toxicity of multiple effluent contaminants could not be addressed by this study.

As discussed in Section 4.1.3, chronic sublethal toxicity of STP effluents to C. dubia was significantly greater in winter compared to summer. This trend was particularly evident for five of the ten STPs (Bracebridge, Lindsay, Midland, North Toronto, and Perth). A similar trend in seasonal toxicity was found in rainbow trout test results and was attributed largely to elevated un-ionized ammonia during winter at four STPs (Highland, Lindsay, Perth, Wallaceburg). With the probable exception of Lindsay STP, elevated C. dubia toxicity in winter could not be attributed to elevated un-ionized ammonia concentrations in winter effluent samples. Most effluents that resulted in greater toxicity in winter also showed seasonal differences in concentration of various effluent parameters (elevated metals, nitrite, BOD, suspended solids, etc., in winter). The seasonal C. dubia trend could not be related to changes in concentration of any single effluent constituent.

### 4.4.6.3 Summary

The data suggested that un-ionized ammonia represented a major effluent toxicant to C. dubia. Various other effluent constituents were identified as potential toxicants (eg., Al, Co, Cr, Cu, Pb, Ni, Sr, Zn), but none could be conclusively associated with C. dubia toxicity. The data indicated that filtered rather than total concentrations of some metals were more meaningful in the evaluation of possible effluent toxicants. As observed in other toxicity tests, BOD and DOC were correlated with effluent toxicity, but their contribution, if any, to effluent toxicity could not be determined.

## 4.4.7 Overview of Effluent Toxicants

### 4.4.7.1 Chlorine

The residual chlorine concentration in STP effluents was an important factor in determining the acute toxicity of the effluents to rainbow trout and D. magna. Removal of TRC from effluent samples, however, did not always result in non-lethality, indicating the presence of other effluent toxicants in some effluents.

### 4.4.7.2 Ammonia

Un-ionized ammonia levels in effluent samples affect the acute lethality of samples to rainbow trout but, at the concentrations observed in this study, had little effect on D. magna lethality. Although the study was designed to minimize acute lethal effects on fathead minnows and C. dubia (ie., in order to identify other potentially important toxicants), effluent un-ionized ammonia likely resulted in chronic sublethal toxicity to those species.

### 4.4.7.3 Sulphide

Elevated sulphide levels are typically associated with lagoon STPs, particularly in winter, when anoxic conditions, leading to sulphide formation, are more likely to prevail. Acute rainbow trout and chronic fathead minnow and C. dubia effects appeared to result, at least in part, from elevated sulphide concentrations in some effluent samples.

### 4.4.7.4 Metals

Metals may have contributed to effluent toxicity particularly in chronic toxicity tests. The data also suggested that metals may have contributed to *D. magna* toxicity, since lower toxicity was associated with the presence of other effluent consituents known to mitigate the toxic effects of metals.

None of the metals identified as potential toxicants was common to all the test types, although both copper and aluminum were associated with toxicity in three of the four test types (trout, minnow, *C. dubia*). Many of the other metals measured in the study were also identified as potential contributers to the toxicity of one or more species.

Evaluation of the toxicity of individual metals was complicated by the potential interaction of the metals with other effluent constituents. For example, some effluent samples may have also contained materials which would reduce the bioavailability of that chemical (Sprague 1985), thereby altering the relative toxicity of a given metal from sample to sample, despite similar measured concentrations. Also, it is possible that the toxicity of some samples resulted from the interactive effects of different metals (Marking 1985). Detailed evaluation of the roles of the above phenomena in STP effluent toxicity was beyond the scope of this study.

### 4.4.7.5 Organic Contaminants

Few organic chemicals were found at detectable levels in STP effluents (Section 3.3). Of those which were detected, most were present at levels below those expected to be toxic to the organisms tested (Table 4.12).

Bis-2-ethylhexylphthalate was found in five samples at concentrations that may have resulted in toxicity, particularly to daphnids. However, all five *Daphnia magna* lethality tests corresponding to those samples were non-lethal, and only one of the *C. dubia* tests showed more than marginal sublethal toxicity.

One sample contained potentially toxic levels of methoxychlor. This pesticide may be more toxic to daphnids than to fish, and the sample toxicity reflected a similar pattern in species sensitivity. This suggests that methoxychlor may have been responsible for, or contributed to, effluent sample toxicity.

## TABLE 4.12: TOXICITY OF ORGANIC CHEMICALS FOUND IN ONTARIO STP EFFLUENTS

| Chemical | Canadian Water Quality Guideline[a] | Concentration Range Observed | Comment |
|---|---|---|---|
| BHC Isomers | 10 ng/L | 10-90 ng/L | Lowest reported toxic effects are in low ug/L range[a,c]; no toxic effects expected |
| Bis-2-ethylhexylphthalate | 0.6 ug/L | 2.0-27 ug/L | Daphnids appear to be most sensitive (in low ug/L range)[a,b]; toxic effects possible |
| Butylbenzylphthalate | none | 2.0 ug/L | Tends to be less toxic than Di-n-butylphthalate[a,b]; no toxic effects expected |
| p,p'-DDT | 1 ng/L | 5-55 ng/L | Chronic effects probably occur at concentrations ten times higher than highest observed effluent concentration[a,d]; no toxic effects expected |
| Di-n-butylphthalate | 4.0 ug/L | 2.0-3.0 ug/L | No toxic effects expected |
| 2,4-D-Propionic Acid<br>2,4-Dichlorophenoxybutyric Acid | none | 100-280 ng/L<br>230-1,300 ng/L | Acid and amine formulations of 2,4-D tend to be less toxic than esters; Canadian Water Quality Guideline for esters is 4,000 ng/L[a]; toxic effects unlikely |
| Heptachlor | 10.0 ng/L | 5.0 ng/L | No toxic effects expected |
| Hexachlorobenzene | 6.5 ng/L | 2.0 ng/L | No toxic effects expected |
| Methoxychlor | none | 180 ng/L | U.S. EPA criterion is 30 ng/L and highest concentration[e]; chronic effects on fathead minnow reported at 125 ng/L[e]; daphnids may be more sensitive than fish[f]; toxic effects possible |

[a] CCREM (1987)
[b] Environment Canada (1983)
[c] U.S. EPA (1980h)
[d] U.S. EPA (1980i)
[e] U.S. EPA (1986)
[f] Mayer and Ellersieck (1986)

Despite the lack of probable cause-effect identified between STP effluent samples and toxicity to aquatic organisms, organics cannot be ruled out as important effluent contaminants. This possibility is particularly emphasized by the fact that the conventional parameters and metals analyzed in this study at most accounted for only about 50 to 60% of the observed toxicity. Although a large number of organic chemicals were analyzed in selected samples, they represent only a fraction of the total number of compounds that may have been present. Anionic surfactants (not measured in this study due to lack of established anaytical techniques for trace concentrations), for example, have been implicated as toxicants in studies of other STP effluents (Esvelt et al., 1973; Higgs, 1977a-g).

Despite the lack of detectable organic contaminants in effluent samples, some data indicated that organic contaminants other than those measured in this study may have contributed to effluent toxicity. Elevated levels of organic substances measured as BOD were frequently correlated with increased sample toxicity (low LC50 or Ch.V.). Increased levels of chemicals measured as dissolved organic carbon were generally associated with increased toxicity in fish tests, and decreased toxicity in daphnid tests. It is not known whether those data represented cause-effect relationships or whether BOD and DOC display co-variance with "true" effluent toxicants.

## 4.5 Validity of Decision Points in Study Design

The decision points outlined in Section 2.5.3 were designed to minimize the effects of TRC and un-ionized ammonia in some tests (particularly chronic tests) to facilitate the identification of any other toxicants that may be common to Ontario STP effluents.

### Sample Dechlorination

Samples were dechlorinated if TRC exceeded 0.1 mg/L. The selected concentration was appropriate to achieve the study objectives, since acute lethality did not consistently occur until TRC levels exceeded 0.1 mg/L. The quantity of data pertaining to both lethal and non-lethal samples was adequate to demonstrate the contribution of TRC to acute effluent toxicity relative to other contaminants measured.

### Un-ionized Ammonia

Each sample was pH adjusted to 6.0 prior to chronic tests if un-ionized ammonia concentrations exceeded 0.1 mg/L and at least 20% mortality occurred in the rainbow trout test. This was intended to result in suppression of un-ionized ammonia concentrations.

Chronic effects were not eliminated when un-ionized ammonia was reduced by the triggers incorporated into the study design, since un-ionized ammonia was identified as a probable toxicant to fathead minnows and, to a lesser degree, to C. dubia. However, un-ionized ammonia concentrations did not account for more than 40% of the variability observed in toxicity test results.

### Analysis of Organic Contaminants

It was recognized, at the outset of the study, that the analysis of only a limited number of parameters may not result in the successful identification of organic toxicants. The data collected were sufficient to indicate that the organic contaminants measured in this study were probably not related to effluent toxicity.

## 4.6 Quality of Data

### 4.6.1 Toxicity Tests

Toxicity laboratory practices complied with U.S. EPA Standards of Good Laboratory Practice (Appendix C). Toxicity tests were performed according to recognized test protocols (Section 2.5.2). Tests were re-set if any abnormalities were observed such as poor control survival or lack of defined dose-response. Regular reference toxicant tests were conducted throughout the study to ensure adequate test precision (Appendix C). The combined result of these activities resulted in the generation of data associated with a high degree of confidence.

### 4.6.2 Chemical Analyses

The majority of the chemistry data were generated by the MOE laboratory which follows a rigorous QA/QC program (Appendix C). Results of blind duplicate analysis and spiked samples also indicated good analytical performance.

Comparison testing of total ammonia and residual chlorine between field and laboratory personnel provided an opportunity to detect and correct deviations in methodology that contributed to analytical variability (Appendix C).

The chemical data presented in this report can be interpreted with a high degree of confidence.

# 5.0 SUMMARY AND CONCLUSIONS

## 5.1 Toxicity of Ontario STP Effluents

### Acute Lethality

Of a total of 123 grab and composite samples collected, 56% were acutely lethal to trout when tested as received. Only one of the ten STPs (Walkerton) produced effluent which was consistently non-lethal to trout during both summer and winter conditions. Forty-three samples contained 0.1 mg TRC/L on arrival at the toxicity laboratory and were therefore split for dechlorination. Of these, 33 (77%) were lethal to trout prior to dechlorination, while 18 (42%) were lethal after dechlorination (see also Section 5.6).

Only 34 samples (27%), tested as received, were lethal to Daphnia magna. Four STPs (Lindsay, Perth, Stratford, Walkerton) produced effluents which were consistently non-lethal to D. magna. Of samples split for dechlorination, only 8 (18%) were lethal after dechlorination, compared to 28 (64%) which were lethal prior to dechlorination.

### Chronic/Sublethal Toxicity

Only a small percentage of the eighty composite samples tested were lethal to fathead minnow larvae (17% samples) and C. dubia (31%) after 7 days of exposure, probably as a result of pre-treatment of some samples (dechlorination, pH-adjustment) to reduce TRC and un-ionized ammonia levels below concentrations expected to cause acute lethality. However, 69% of those samples caused reduced growth of fathead minnow larvae and 56% (45 samples) impaired reproduction among C. dubia. At least one sample from each STP caused sublethal effects on fathead minnow larvae and C. dubia, although it was not necessarily the same sample which affected both species.

Despite the fact that only samples with reduced TRC and un-ionized ammonia were tested for sublethal toxicity, the sublethal end-points (eg., growth, reproduction) of the C. dubia and fathead minnow tests were a more sensitive measure of effluent toxicity than lethality. Therefore, sublethal tests could be used for more stringent (protective) control of effluent quality.

## 5.2 Comparison of Species and Test Sensivity

Aquatic organisms are not equally sensitive to individual chemicals. Therefore, when exposed to the complex mixture of chemicals contained in an STP effluent sample, different test species may be expected to respond differently. Although a greater proportion of STP effluent samples were acutely lethal to rainbow trout (52% of all tests conducted on as-received and dechlorinated samples) compared to *Daphnia magna* (23%), neither species was consistently more sensitive to individual samples. Similarly, sublethal effluent toxicity to any given samples was not consistently greater for fathead minnows compared to *Ceriodaphnia dubia*, or vice versa. Consequently, effluent monitoring performed using only a single test species will not necessarily reflect the toxicity to other aquatic species.

## 5.3 Effect of Effluent Sampling Procedure on Toxicity Test Results

There was no statistically significant difference between acute rainbow trout LC50 distributions of grab versus composite samples collected from the ten STPs. Although firm conclusions were not possible for *Daphnia magna*, due to the small number of acutely lethal samples, there did not subjectively appear to be a difference in LC50 distribution which could be ascribed to differences in sampling procedure. Results of toxicity tests conducted on grab samples (both species) agreed more than 77% of the time in summer and more than 95% of the time in winter with results based on corresponding composite samples in differentiating between a lethal and non-lethal effluent.

## 5.4 Effect of Industrial Loading on Effluent Toxicity

The influence of industrial loading on effluent toxicity was assessed based on a subjective rating of the industrial loading to each STP and a small number of STPs in each category. Based on the limited number of STPs in each of the industrial loading categories, rainbow trout acute lethality data suggested a trend toward less toxic effluent at STPs classified as having a "low" industrial load contribution. However, the differences were not significant at the 95% confidence level. *Daphnia magna* acute toxicity test data did not support detailed analysis because of the low number of lethal samples. The results of the *C. dubia* test showed a trend toward greater chronic effect as the industrial plant load increased. The differences in C. dubia toxicity of effluents from STPs categorized as receiving a "low" industrial load compared to those categorized as receiving a "high" industrial load were significant. Chronic fathead minnow tests could not identify a statistically significant difference in effluent toxicity related to industrial wastewater loading.

### 5.5 Effect of STP Operating Conditions on Effluent Sample Toxicity

Effluent samples collected under cold weather operating conditions exhibited more acute toxicity (ie., lower LC50 distribution) to rainbow trout than samples collected from the same STPs under warm weather conditions. This trend was largely the result of elevated un-ionized ammonia concentrations in winter samples from four of the ten STPs. Although summer samples were more frequently lethal to Daphnia magna than winter samples, no statistically supportable conclusions could be drawn regarding seasonal effects due to the low number of acutely lethal samples.

Samples collected under cold weather conditions resulted in more chronic toxicity to Ceriodaphnia dubia, but this trend could not be attributed to seasonal differences in any single parameter relating to effluent processes. There was no significant difference in chronic toxicity of effluents to fathead minnows in summer vs. winter.

Lagoon effluent samples collected in cold weather conditions were more toxic in terms of both acute and chronic test results than those collected in warm weather conditions, and seemed to be associated with elevated sulphide and/or un-ionized ammonia concentrations in winter.

No statistically significant differences in acute or chronic toxicity could be related to plant process type (ie., secondary, tertiary, or lagoon).

STP operation at less than 80 percent of the rated hydraulic capacity of the facility did not significantly affect the acute or chronic toxicity of plant effluent compared to operation near or above the rated plant capacity based on these data.

Conclusive effects of other operating conditions in secondary STPs (F/M ratio, SRT, aeration basin HRT) on the acute or chronic toxicity of the STP effluent are difficult to define due to the limited database (six STPs) and possible influences of other uncontrolled variables. These data suggest that effluents from plants operating with an aeration basin HRT longer than six hours are less toxic to trout than those with HRT greater than six hours. However, the data also suggest that effluents from plants operated at higher organic loadings had less sublethal effect on fathead minnow and C. dubia than plants with lower organic loading. Further controlled experimentation would be needed to confirm these findings.

## 5.6 Contaminants Associated With Toxicity

Multiple regression analysis was the procedure used to identify the relative contribution of specific toxicants in STP effluent samples. In general, concentrations of conventional parameters and metals accounted for less than 60% of the variability observed in toxicity test results. Potential explanations for this include the following:

- Since the relative importance of many toxicants varies between STPs the analyses would not be expected to identify chemicals which contributed to toxicity in only a few STP effluents.

- The chemical concentrations used in the analyses were those measured in samples collected at the beginning of each toxicity test. Since the concentration of some chemicals changed during tests (eg., nitrogen species), the results of some toxicity tests may not have reflected initial chemical concentrations. Consequently, the ability of regression analyses to identify chemical concentration-toxicity relationships would be decreased.

- Complex phenomena such as potential toxicant interactions could not be evaluated within the scope of this study.

The second type of analysis performed involved the comparsion of measured effluent chemical concentrations to their corresponding toxic concentrations as documented in the literature. While this approach also identified a number of potential or probable toxicants in the STP effluents, definitive conclusions were not possible. One explanation for this is that the toxic concentrations of each chemical documented in the literature represent only estimates, since the potency of many toxicants may be altered by other constituents in solution (e.g., Ca and Mg (hardness, alkalinity), hydrogen ions (pH), other toxicants). In addition, the latter two of the three points presented above likely apply.

In spite of the above limitations, there was evidence of toxic contribution of specific chemicals measured in this study.

Chlorinated effluents were more lethal to rainbow trout and Daphnia magna than dechlorinated effluents. TRC concentrations measured in effluent samples at the time of arrival at the toxicity laboratory were negatively correlated with LC50 values. TRC was, therefore, identified as one of the most important chemical parameters in determining effluent lethality in acute tests, and samples with initial TRC concentrations of about 0.2 mg/L or more were usually lethal to trout and D. magna. (The potential effects of TRC on chronic toxicity were not evaluated in this study.)

Un-ionized ammonia was also identified as an important toxicant, with samples containing initial concentrations above approximately 0.1 mg/L often being lethal to trout. Ammonia was also an important toxicant in chronic fathead minnow and C. dubia tests, even though sample pH was reduced in some tests to reduce the amount of ammonia present in the un-ionized (more toxic) form.

Concentrations of non-specific parameters such as BOD, dissolved organic carbon, and suspended solids appeared to be related to some of the variability observed in toxicity test results. That $BOD_5$ and DOC were frequently negatively correlated with toxicity test end-points (eg., LC50, Ch.V.), particularly in fish tests, suggested that organic contaminants may have contributed to effluent toxicity. None of the specific organic contaminants measured in selected effluent samples, however, could be conclusively related to observed toxicity.

Elevated sulphide levels in lagoon samples were associated with increased toxicity in both acute and chronic tests.

Metals appeared to be associated with the toxicity of some effluent samples, particularly in acute tests with Daphnia magna, and in chronic tests. Conclusive evaluation of metal toxicity was confounded by potential interactions between any given metal and other effluent constituents (including other metals).

## 5.7 Factors Affecting Assessment of Effluent Toxicity

Chemical analyses of total ammonia and residual chlorine conducted in the field at the time of sample collection and again after immediate delivery of the samples to the toxicity laboratory showed decreases in the concentrations of both parameters during transportation.

Changes in physical/chemical properties of effluent samples which occur during toxicity testing (e.g., nitrogen speciation, pH), may affect the outcome of toxicity test results.

Generally less than 50% of the observed variation in toxicity test data could be explained by variations in measured chemical concentrations. Interpretation of all toxicity test results in terms of chemical levels involved evaluation of the toxicity of each contaminant independent of other contaminants. The effects of additive, synergistic, or antagonistic interactions among contaminants could not be addressed in this study, but such factors likely account for some toxicity that could not be attributed to individual contaminants.

# 6.0 RECOMMENDATIONS

1. Species sensitivity rankings varied among effluent samples, indicating that discharge limits which are based on the toxicity of the effluent to a single species may not be protective for other aquatic organisms. It is recommended that future assessments of Ontario STP effluent toxicity be conducted using more than one aquatic species, preferably representative of different trophic levels.

2. TRC and un-ionized ammonia were identified as the primary determinants of effluent lethality to rainbow trout and to Daphnia magna. The Ministry should focus initially on reductions in TRC and ammonia to significantly reduce the toxicity of STP effluents.

3. Chronic toxicity of Ontario STP effluents was frequently observed at concentrations lower than those causing acute toxicity. After initial efforts to reduce acute lethality of STP effluents are complete, it is recommended that efforts be directed toward the reduction of chronic/sublethal effluent toxicity.

4. Because there was little difference between composite and grab samples in judging whether a sample was acutely lethal, grab sampling is recommended in future monitoring programs of STP effluent toxicity, except where program objectives or effluent variability dictate otherwise.

5. Since seasonal differences were observed in the toxicity of STP effluents, it is recommended that future toxicity monitoring programs incorporate both summer and winter operating conditions.

6. The effect of STP operating conditions (SRT, HRT, F/M, etc.) on effluent toxicity needs to be further assessed before definitive conclusions can be drawn. This would require controlled parallel experimentation with the same wastewater so that only one parameter is varied at a time.

7. For STPs showing acute effluent toxicity that cannot be primarily related to TRC or ammonia, it is recommended that investigative techniques such as those developed by the U.S. EPA (Toxicity Identification and Reduction Evaluation - TI/RE - Mount and Anderson-Carnahan, 1988, 1989; Botts et al., 1989; Mount, 1989) be used to identify toxicants.

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# APPENDIX A

## Descriptions of STPs and Sampling Locations

## APPENDIX A: DESCRIPTIONS OF STPs AND SAMPLING LOCATIONS

Ten Ontario sewage treatment plants (STPs) were included in the effluent toxicity monitoring, as identified previously (Section 2.1, Table 2.2). Included among these ten STPs were six secondary treatment facilities, two tertiary facilities and two lagoons. All facilities practised phosphorus removal by chemical addition. The plants ranged in size from 3,200 $m^3$/d (0.7 MIGD) to 218,200 $m^3$/d (48 MIGD). In all cases except Perth, the average daily flow for 1988 was less than the rated hydraulic capacity of the plant as summarized in Table A.1.

### A.1 Bracebridge STP

### A.1.1 Description of Facility

The Bracebridge STP is an extended aeration plant which provides for effluent polishing by multi-media filtration. Alum is added to the mixed liquor upstream of the secondary clarifiers for phosphorus removal. The filtered effluent is chlorinated year-round prior to discharge to the Muskoka River. Stabilization lagoons are available to handle peak flows. Raw sewage is diverted at a distribution box downstream of grit removal to either of two lagoon cells. Two other cells are presently out of service. A minimum hydraulic retention time of 30 days is maintained in the lagoons and the lagoons are batch-treated with alum prior to discharge via the plant outfall. Flow equalization is also achieved in the aeration basin by surging the liquid level at high flow conditions.

A schematic of the Bracebridge STP is shown in Figure A.1. Rated capacity of the facility is 3,190 $m^3$/d (0.7 MIGD). The lagoon system provides an additional capacity of 2,040 $m^3$/d (0.45 MIGD) for peak flows. Key design data for the facility are shown in Figure A.1.

### A.1.2 Historical Performance

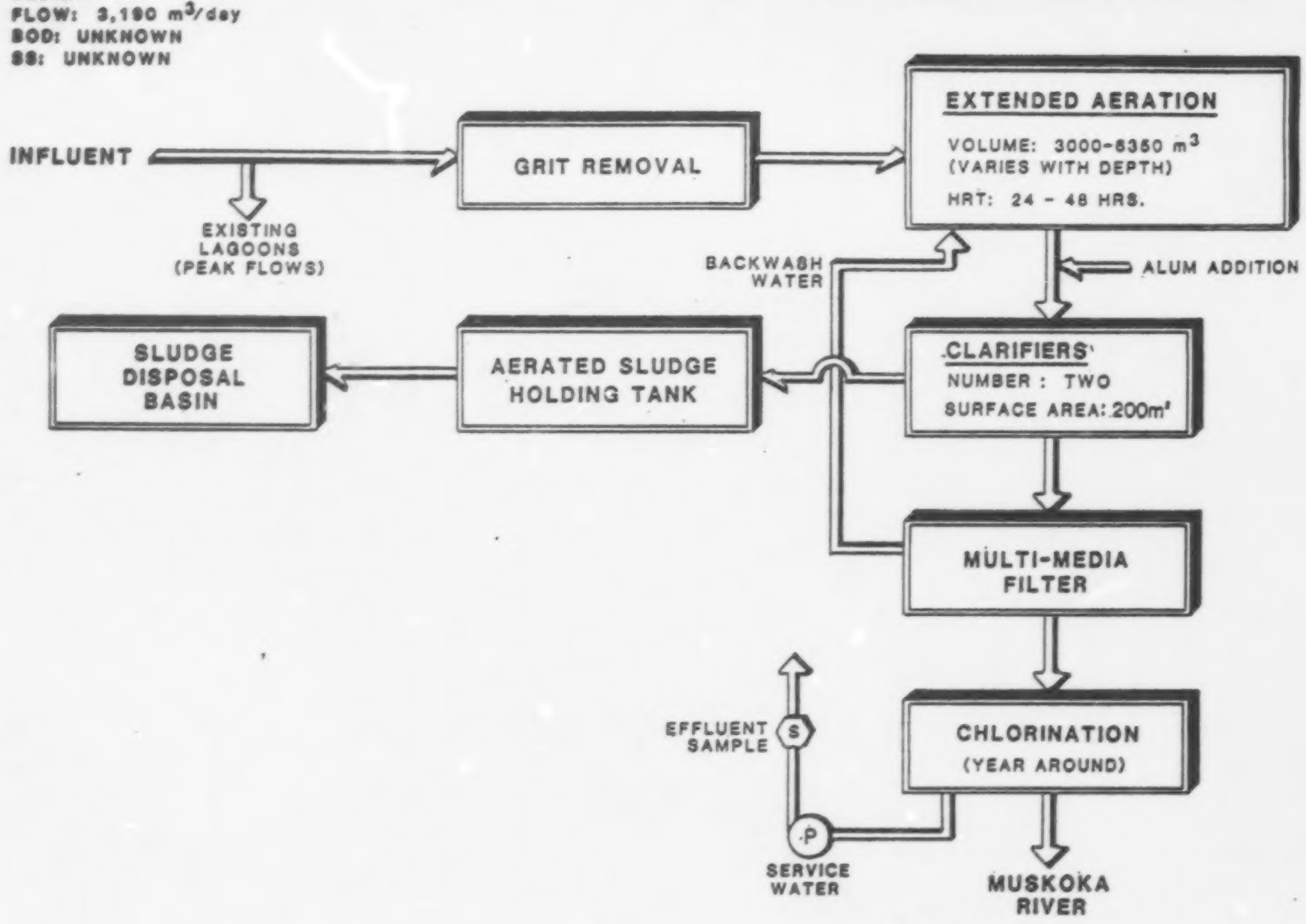
The historical performance of the Bracebridge STP is summarized in Table A.2, based on 1988 operating records. The facility in 1988 operated at approximately 82 percent of rated capacity and consistently produced a high quality effluent averaging 3 mg/L $BOD_5$,

## Table A.1

## DESCRIPTION OF STPs INCLUDED IN SAMPLING PROGRAM

| | STP | Type | Operating Authority | Flow (1,000 $m^3$) Design | Flow (1,000 $m^3$) 1988 Average |
|---|---|---|---|---|---|
| 1. | Bracebridge | Extended Aeration<br>Effluent Filtration<br>P Removal | Municipal | 3.19 | 2.60 |
| 2. | Highland Creek (Toronto) | Conventional Activated Sludge<br>P Removal | Municipal | 218.20 | 151.69 |
| 3. | Huntsville | Conventional Activated Sludge<br>P Removal | Municipal | 4.55 | 3.89 |
| 4. | Lindsay | Conventional Lagoon<br>P Removal<br>Continuous Discharge | Municipal | 17.18 | 13.55 |
| 5. | Midland | Conventional Activated Sludge<br>P Removal | Municipal | 13.64 | 11.32 |
| 6. | North Toronto | Conventional Activated Sludge<br>P Removal | Municipal | 45.46 | 34.87 |
| 7. | Perth | Conventional Lagoon<br>P Removal<br>Continuous Discharge | Municipal | 5.91 | 6.11 |
| 8. | Stratford | Conventional Activated Sludge<br>Effluent Filtration<br>P Removal | MOE | 27.28 | 22.06 |
| 9. | Walkerton | Conventional Activated Sludge<br>P Removal | Municipal | 7.55 | 4.74 |
| 10. | Wallaceburg | Conventional Activated Sludge<br>P Removal | MOE | 6.81 | 6.12 |

# FIGURE A.1: BRACEBRIDGE WPCP


DESIGN:
FLOW: 3,190 m³/day
BOD: UNKNOWN
SS: UNKNOWN
INFLUENT
EXISTING LAGOONS (PEAK FLOWS)
GRIT REMOVAL
EXTENDED AERATION
VOLUME: 3000-6350 m³ (VARIES WITH DEPTH)
HRT: 24 - 48 HRS.
ALUM ADDITION
BACKWASH WATER
CLARIFIERS
NUMBER : TWO
SURFACE AREA: 200m²
MULTI-MEDIA FILTER
CHLORINATION (YEAR AROUND)
MUSKOKA RIVER
EFFLUENT SAMPLE
S
P
SERVICE WATER
AERATED SLUDGE HOLDING TANK
SLUDGE DISPOSAL BASIN

## Table A.2

## HISTORICAL PERFORMANCE DATA (1988) OF BRACEBRIDGE STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) BOD$_5$ | TSS | TP | Effluent Quality (mg/L) BOD$_5$ | TSS | TP |
|---|---|---|---|---|---|---|---|
| January | 2170 | 115 | 88 | 8.3 | 3.8 | 5.7 | 0.3 |
| February | 2310 | 99 | 77 | 5.4 | 2.6 | 3.5 | 0.2 |
| March | 2260 | 58 | 52 | 4.2 | 2.7 | 5.9 | 0.2 |
| April | 2310 | 43 | 52 | 3.1 | 1.8 | 3.1 | 0.1 |
| May | 2570 | 87 | 56 | 5.5 | 2.0 | 1.8 | 0.1 |
| June | 2670 | 117 | 123 | 6.1 | 2.6 | 2.4 | 0.1 |
| July | 2760 | 366 | 190 | 7.3 | 2.1 | 2.1 | 0.2 |
| August | 3010 | 143 | 165 | 5.9 | 3.9 | 6.1 | 0.4 |
| September | 2660 | 112 | 96 | 6.1 | 7.1 | 1.7 | 0.1 |
| October | 2700 | 144 | 134 | 4.6 | 1.2 | 2.3 | 0.1 |
| November | 3010 | 211 | 198 | 6.5 | 4.0 | 1.9 | 0.3 |
| December | 2810 | 118 | 58 | 10.0 | 3.4 | 1.5 | 0.2 |
| Overall | 2600 | 134.4 | 107.4 | 6.1 | 3.1 | 3.2 | 0.2 |

ND = No Data

3 mg/L TSS and 0.2 mg/L TP. The Bracebridge STP was in compliance with all effluent quality guidelines in 1988.

### A.1.3 Industrial Contribution to Plant Influent

According to town officials, there are no significant industrial contributors tributary to the Bracebridge STP. Industrial survey information shows that there are several commercial establishments which discharge to the municipal treatment plant. No estimate of the total flow contribution was available.

### A.1.4 Sampling Location

Due to the distance of the chlorine contactor at the Bracebridge STP below grade and accessibility problems for the refrigerated sampling equipment, the final effluent composite sample was collected from the recirculating service water pump in the plant which returned chlorinated final effluent for a variety of in-plant purposes. A sample tap on the service water line in the plant laboratory was run continuously into a glass container. Service water overflowed continuously from the container throughout the sampling period. This sampling location is identified in Figure A.1.

### A.1.5 Operating Conditions

The operating conditions at the Bracebridge STP in the two weeks immediately prior to the summer and winter sampling periods are summarized in Table A.3. These operating parameters were calculated based on the plant's routine operating log sheets and samples submitted by plant staff for regular analysis by MOE.

Flows to the plant were lower than the 1988 average during both periods. During the winter sampling period, the average flow was only 63 percent of design. The relatively low flows resulted in aeration basin hydraulic retention times (HRTs) of near 50 hours. As characteristic of extended aeration systems, organic loadings were relatively low (0.03 g BOD/g VSS.d) and solids retention times (SRTs) exceeded 15 days based on plant records of sludge wastage from the system. Raw wastewater strength was typical of the historic characteristics during both sampling periods.

## TABLE A.3: BRACEBRIDGE STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 2,430 | 2,000 |
| Percent of Design Flow | 76 | 63 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 138.0 | 177.6 |
| TSS (mg/L) | 128.8 | 117.0 |
| TP (mg/L) | 6.63 | 5.63 |
| Aeration Tank HRT (h) | 46.3 | 56.2 |
| SRT (d) | 15.4 | 15.7 |
| F:M Ratio ($d^{-1}$) | 0.034 | 0.032 |

## A.2 Highland Creek (Toronto) STP

### A.2.1 Description of Facility

The Highland Creek STP serves the City of Scarborough in the Municipality of Metropolitan Toronto. It is a 218,200 $m^3$/d (48 MIGD) conventional activated sludge plant which incorporates three separate 72,700 $m^3$/d (16 MIGD) plants downstream of a common headworks. The layout of the facility is shown in Figure A.2, along with key design parameters.

Sludges (waste activated and primary) produced by the liquid treatment train are incinerated in a multiple hearth incinerator after DAF thickening, anaerobic digestion of a portion of the sludge flow, heat treatment by the Porteous process and centrifugal dewatering. The decant liquors from the heat treatment system are returned to the plant. An anaerobic filter has been installed to pretreat the heat treatment liquor, but the system was not operational during this sampling program. Secondary effluent is chlorinated year-round and discharged to Lake Ontario. The outfall pipe serves as the chlorine contact chamber.

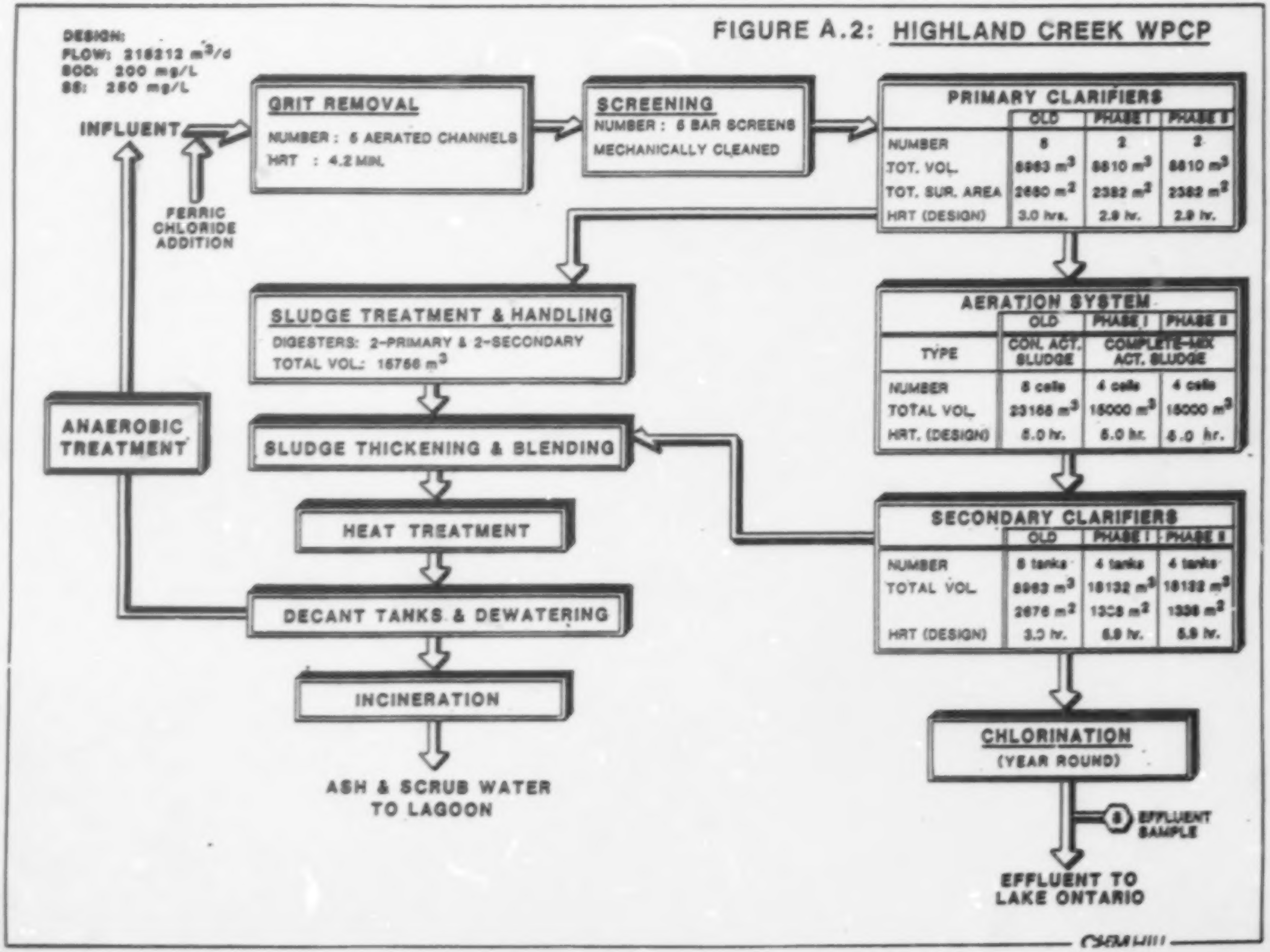
### A.2.2 Historical Performance

The historical performance of the Highland Creek STP is summarized in Table A.4, based on 1988 operating records. In 1988, the facility operated at approximately 70 percent of design flow and produced an effluent which was consistently in compliance with its effluent quality guidelines. Average effluent quality in 1988 was 8.7 mg/L $BOD_5$, 17.7 mg/L TSS and 0.7 mg/L TP.

### A.2.3 Industrial Contribution to Plant Influent

A diverse range of industries discharge to the Highland Creek STP. An inventory of industries in the catchment area indicates that there are approximately 880 establishments representing 54 SIC groups. Major industrial categories, in terms of number of industries, include textile manufacturers (SICs 22/23; 33 establishments), furniture manufacturers (SIC 25; 43 establishments), converted paper products (SIC 26; 37 establishments), printing and publishing (SIC 27; 134 establishments), metal finishing

FIGURE A.2: HIGHLAND CREEK WPCP


DESIGN:
FLOW: 216212 m³/d
BOD: 200 mg/L
SS: 250 mg/L
INFLUENT
FERRIC CHLORIDE ADDITION
GRIT REMOVAL
NUMBER : 5 AERATED CHANNELS
HRT : 4.2 MIN.
SCREENING
NUMBER : 5 BAR SCREENS
MECHANICALLY CLEANED
SLUDGE TREATMENT & HANDLING
DIGESTERS: 2-PRIMARY & 2-SECONDARY
TOTAL VOL.: 15756 m³
SLUDGE THICKENING & BLENDING
HEAT TREATMENT
DECANT TANKS & DEWATERING
INCINERATION
ASH & SCRUB WATER TO LAGOON
ANAEROBIC TREATMENT
CHLORINATION
(YEAR ROUND)
8 EFFLUENT SAMPLE
EFFLUENT TO LAKE ONTARIO

**PRIMARY CLARIFIERS**

| | OLD | PHASE I | PHASE II |
|---|---|---|---|
| NUMBER | 8 | 2 | 2 |
| TOT. VOL. | 8963 m³ | 8810 m³ | 8810 m³ |
| TOT. SUR. AREA | 2680 m² | 2382 m² | 2382 m² |
| HRT (DESIGN) | 3.0 hrs. | 2.9 hr. | 2.9 hr. |

**AERATION SYSTEM**

| | OLD | PHASE I | PHASE II |
|---|---|---|---|
| TYPE | CON. ACT. SLUDGE | COMPLETE-MIX ACT. SLUDGE | |
| NUMBER | 8 cells | 4 cells | 4 cells |
| TOTAL VOL. | 23168 m³ | 15000 m³ | 15000 m³ |
| HRT. (DESIGN) | 6.0 hr. | 6.0 hr. | 6.0 hr. |

**SECONDARY CLARIFIERS**

| | OLD | PHASE I | PHASE II |
|---|---|---|---|
| NUMBER | 8 tanks | 4 tanks | 4 tanks |
| TOTAL VOL. | 8963 m³ | 16132 m³ | 16132 m³ |
| | 2676 m² | 1338 m² | 1338 m² |
| HRT (DESIGN) | 3.0 hr. | 5.9 hr. | 5.9 hr. |

Table A.4

## HISTORICAL PERFORMANCE DATA (1988) OF HIGHLAND CREEK STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 139,300 | 186 | 216 | 5.2 | 10.8 | 20.4 | 0.7 |
| February | 133,900 | 177 | 214 | 5.2 | 9.8 | 22.2 | 0.6 |
| March | 141,600 | 175 | 199 | 4.9 | 7.0 | 12.3 | 0.6 |
| April | 146,100 | 155 | 191 | 5.3 | 7.4 | 14.3 | 0.6 |
| May | 151,060 | 171 | 213 | 5.2 | 9.4 | 15.6 | 0.7 |
| June | 175,100 | 167 | 229 | 5.3 | 12.7 | 21.0 | 0.9 |
| July | 180,100 | 171 | 212 | 4.7 | 12.3 | 19.8 | 0.7 |
| August | 176,400 | 160 | 198 | 4.7 | 7.9 | 20.8 | 0.6 |
| September | 156,100 | 174 | 260 | 5.7 | 6.0 | 12.5 | 0.7 |
| October | 149,940 | 177 | 239 | 5.5 | 6.8 | 16.1 | 0.9 |
| November | 141,800 | 173 | 228 | 4.7 | 6.7 | 13.9 | 0.7 |
| December | 128,900 | 156 | 197 | 4.8 | 7.9 | 23.1 | 1.0 |
| Overall | 151,690 | 170.2 | 216.3 | 5.1 | 8.7 | 17.7 | 0.7 |

ND = No Data

(SIC 34; 71 establishments), machinery manufacturing (SIC 35; 165 establishments) and electrical and electronic component manufacturers (SIC 36; 80 establishments). Significant contributors include chemical, pharmaceutical and resin manufacturers and paper producers. Based on water use data, it is estimated that the industrial contribution to the Highland Creek STP is in the range of about 20 percent of the total plant flow.

### A.2.4 Sampling Location

As the outfall diffuser is used for chlorine contact at the Highland Creek STP, final effluent is not readily accessible for sampling. Therefore, the chlorinated service water line recirculating to the plant's online chlorine residual analyzer and final effluent sampler was used to provide the sample for toxicity testing. The service water line discharges into a continuous overflowing pot in the DAF building at the plant. This was the sampling location used for the effluent toxicity monitoring program.

### A.2.5 Operating Conditions

The operating conditions at the Highland Creek STP immediately prior to the summer and winter sampling periods are summarized in Table A.5. These operating parameters were calculated based on the plant's routine monitoring log sheets and regular samples collected and analyzed by the operating authority.

Flows to the plant during both sampling periods were higher than the 1988 average and approached 90 percent of design during the summer sampling period. Despite the relatively high volumetric loading on the biological system, the F:M ratios were relatively low (0.11 to 0.16 g BOD/g VSS.d) due to the high MLSS concentrations which are maintained in the system aeration tanks. SRTs reported in Table A.5 are estimated based on the organic loading since operating logs at Highland Creek do not include the data required to calculate SRT.

## A.3 Huntsville STP

### A.3.1 Description of Facility

The Huntsville STP is a conventional activated sludge plant designed to handle an average daily flow of 4,500 $m^3/d$ (1 MIGD). As shown in the plant schematic in

## TABLE A.5: HIGHLAND CREEK STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 193,930 | 166,950 |
| Percent of Design Flow | 89 | 77 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 158.8 | 132.2 |
| TSS (mg/L) | 221.7 | 221.7 |
| TP (mg/L) | 4.68 | 4.87 |
| Aeration Tank HRT (h) | 6.6 | 7.6 |
| SRT (d) | 10.3 | 15.0 |
| F:M Ratio ($d^{-1}$) | 0.16 | 0.11 |

Figure A.3, the facility consists of two parallel secondary plants downstream of a common headworks and primary clarifiers. The old plant is designed to handle 1,350 $m^3/d$ (0.3 MIGD) while the new plant has a design capacity of 3,150 $m^3/d$ (0.7 MIGD). Alum is added to the mixed liquor for phosphorus removal. Sludges are anaerobically digested prior to land disposal.

Chlorination of the secondary effluent is practised year-round in a conventional chlorine contact chamber. Effluent is discharged to the Muskoka River. Design data for the facility are included in Figure A.3.

### A.3.2 Historical Performance

The historical performance of the Huntsville STP is summarized in Table A.6, based on 1988 operating records. During this period, the facility operated at approximately 86 percent of design flow, although high flows were evident in the spring months (March, April, May). The plant produced a high quality secondary effluent, meeting all effluent quality guidelines. Average effluent quality in 1988 was 4.6 mg/L $BOD_5$, 7.7 mg/L TSS and 0.3 mg/L TP.

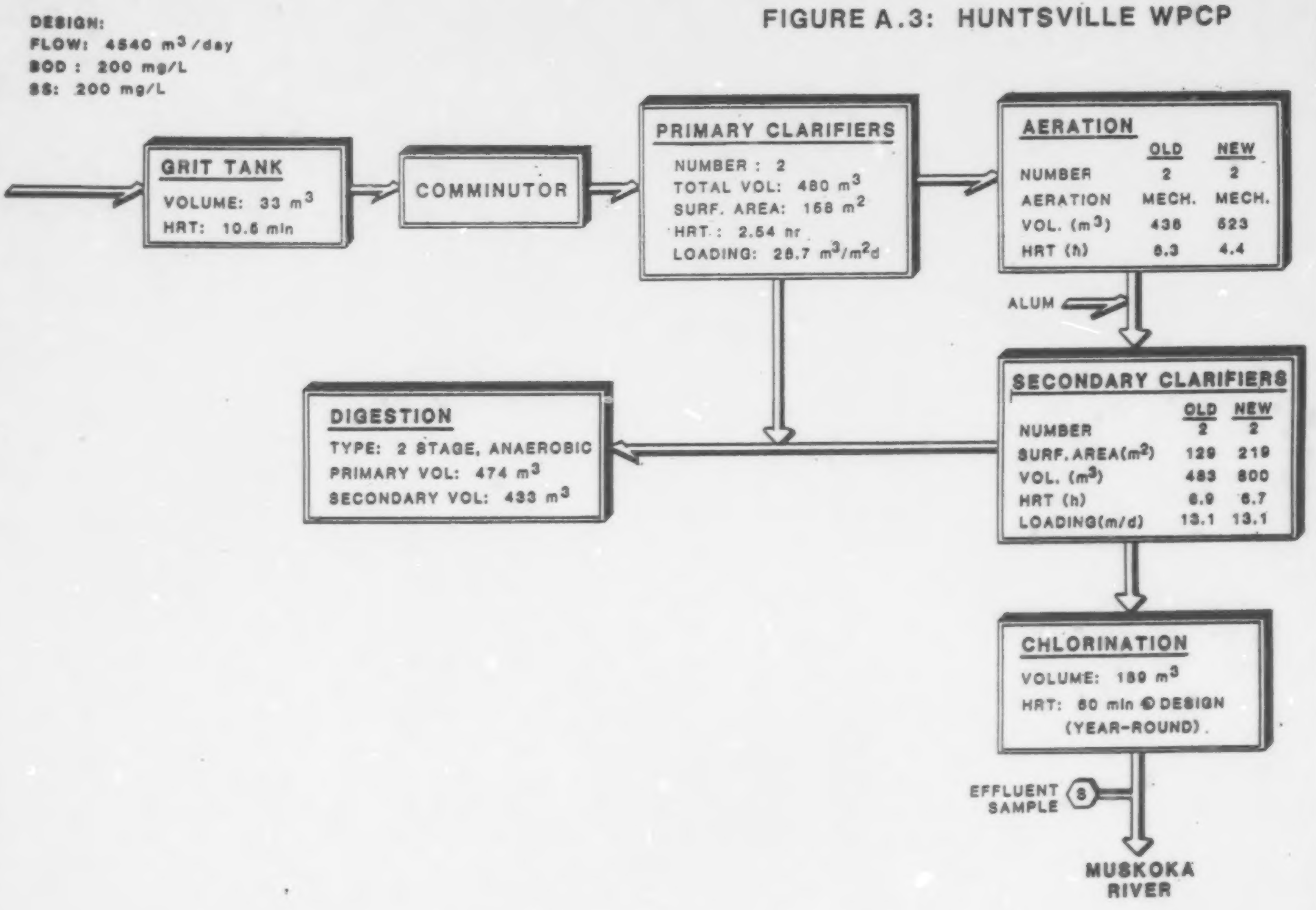
### A.3.3 Industrial Contribution to Plant Influent

According to town officials, there are no significant industrial dischargers tributary to the Huntsville STP. An inventory of industries in the town indicates several timber products producers and plastic product manufacturers. No estimate of water use or wastewater flow from these establishments was available.

### A.3.4 Sampling Location

Composite samples at the Huntsville STP were collected at the discharge of the chlorine contactor at the inlet of the plant outfall. Sample suction lines were located 60 cm downstream of the pipe inlet and approximately 3 cm off the pipe invert at a location to ensure that the overflows from the parallel contactors were well-mixed.

## FIGURE A.3: HUNTSVILLE WPCP


DESIGN:
FLOW: 4540 m³/day
BOD : 200 mg/L
SS: 200 mg/L
GRIT TANK
VOLUME: 33 m³
HRT: 10.5 min
COMMINUTOR
PRIMARY CLARIFIERS
NUMBER : 2
TOTAL VOL: 480 m³
SURF. AREA: 158 m²
HRT : 2.54 hr
LOADING: 28.7 m³/m²d
AERATION
OLD NEW
NUMBER 2 2
AERATION MECH. MECH.
VOL. (m³) 438 523
HRT (h) 5.3 4.4
ALUM
SECONDARY CLARIFIERS
OLD NEW
NUMBER 2 2
SURF. AREA(m²) 129 219
VOL. (m³) 483 800
HRT (h) 6.9 6.7
LOADING(m/d) 13.1 13.1
DIGESTION
TYPE: 2 STAGE, ANAEROBIC
PRIMARY VOL: 474 m³
SECONDARY VOL: 433 m³
CHLORINATION
VOLUME: 189 m³
HRT: 60 min @ DESIGN
(YEAR-ROUND)
EFFLUENT SAMPLE
S
MUSKOKA RIVER
CH2M HILL

## Table A.6

## HISTORICAL PERFORMANCE DATA (1988) OF HUNTSVILLE STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 3420 | 109 | 118 | 5.6 | 7.0 | 6.5 | 0.4 |
| February | 3870 | 117 | 176 | 5.6 | 6.8 | 11.7 | 0.5 |
| March | 4120 | 80 | 98 | 3.9 | 3.9 | 10.6 | 0.4 |
| April | 5840 | 51 | 79 | 2.6 | 4.5 | 15.1 | 0.3 |
| May | 4210 | 77 | 121 | 4.8 | 2.6 | 7.1 | 0.1 |
| June | 3590 | 113 | 116 | 5.0 | 4.8 | 5.7 | 0.2 |
| July | 3520 | 141 | 123 | 5.5 | 3.9 | 5.2 | 0.2 |
| August | 3640 | 128 | 142 | 5.1 | 2.9 | 4.3 | 0.2 |
| September | 3090 | 185 | 170 | 6.2 | 2.6 | 5.8 | 0.3 |
| October | 3620 | 13 | 125 | 5.4 | 3.1 | 5.6 | 0.2 |
| November | 4240 | 90 | 90 | 3.9 | 10.0 | 6.5 | 0.2 |
| December | 3520 | 38 | 27 | 2.3 | 3.2 | 9.1 | 0.3 |
| Overall | 3890 | 95.2 | 115.5 | 4.7 | 4.6 | 7.7 | 0.3 |

ND = No Data

### A.3.5 Operating Conditions

The operating conditions at the Huntsville STP immediately prior to the summer and winter sampling periods are summarized in Table A.7. These operating parameters were calculated based on the plant's routine operating log sheets and samples submitted by plant staff for regular analysis by MOE.

Flows to the Huntsville STP were near 1988 average levels during the summer sampling period but were higher than design during the winter period. Despite the higher hydraulic loadings in the winter, organic loadings to the system were actually lower than during the summer period. Waste strength was substantially higher during the summer sampling period than during the winter, which is reflected in the higher F:M ratio during this period. This pattern is also reflected in the historical data and is probably associated with the summer tourist trade in the Huntsville area. SRTs were estimated based on the F:M ratio as the operating logs did not provide the data needed for the calculation. During both sampling periods, the SRT was estimated to be less than 3 days.

## A.4 Lindsay STP

### A.4.1 Description of Facility

The Lindsay STP, shown schematically in Figure A.4, consists on parallel aeration cells upstream of facultative lagoons. Rated capacity of the facility is 17,180 $m^3/d$ (3.8 MIGD). Key design data for the facility are shown on Figure A.4. Alum is added to the aeration cell effluent upstream of the lagoons for phosphorus removal. Chlorination of the lagoon effluent is not practised prior to discharge to the Scugog River. The Lindsay STP was undergoing modifications for upgrading and expansion during 1989. However, these activities did not impact on the operation of the facility during the sampling period.

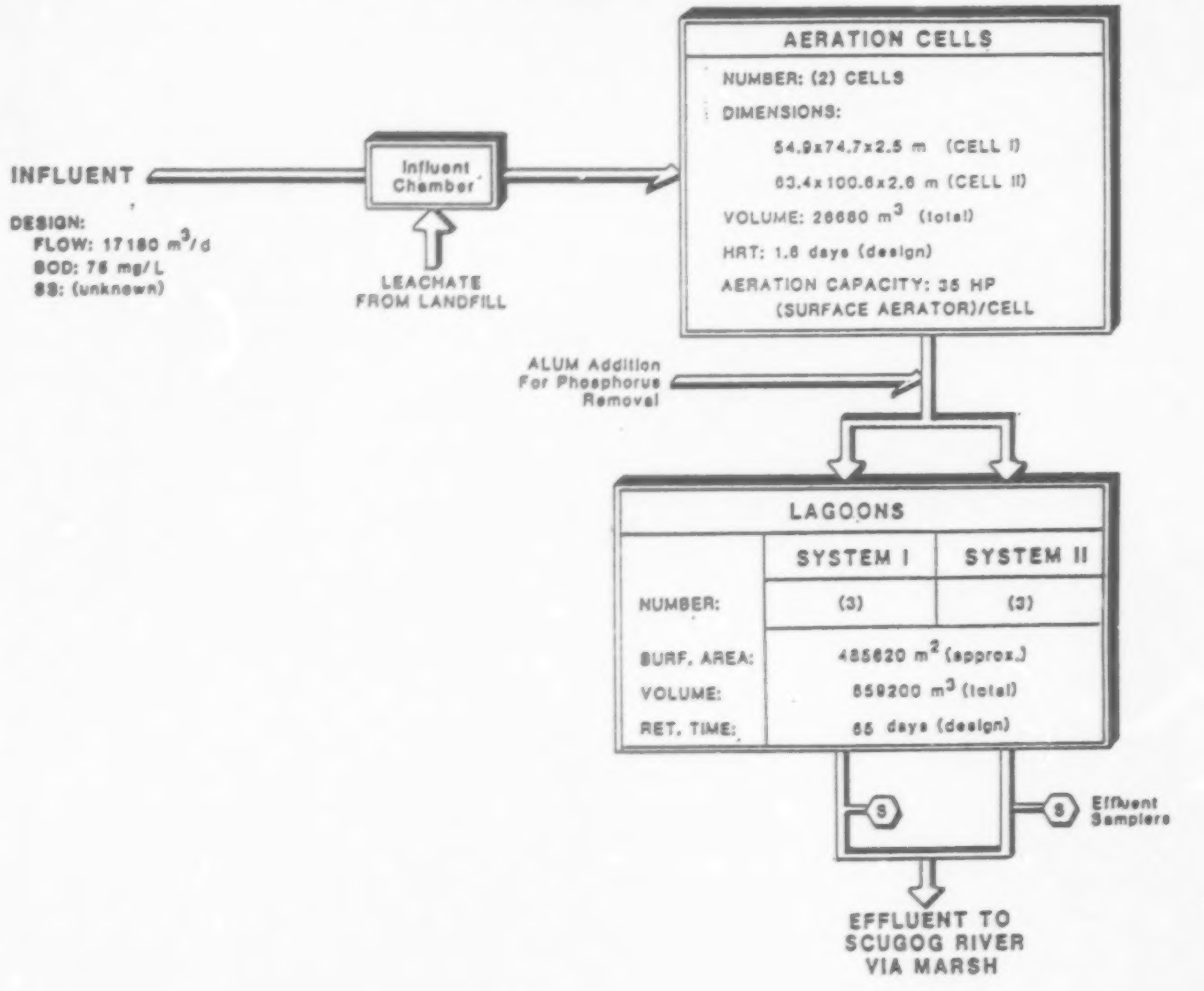
### A.4.2 Historical Performance

The historical performance of the Lindsay STP is summarized in Table A.8, based on 1988 operating results. During this period, the plant operated at approximately 79 percent of rated hydraulic capacity. Effluent quality was consistently good, averaging 9.0 mg/L

## TABLE A.7: HUNTSVILLE STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 3,720 | 4,680 |
| Percent of Design Flow | 82 | 103 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 156 | 87 |
| TSS (mg/L) | 142.0 | 97.6 |
| TP (mg/L) | 8.35 | 4.84 |
| Aeration Tank HRT (h) | 6.2 | 4.9 |
| SRT (d) | 1.4 | 2.7 |
| F:M Ratio ($d^{-1}$) | 0.45 | 0.23 |

## FIGURE A.4: LINDSAY LAGOONS


INFLUENT
DESIGN:
FLOW: 17180 m³/d
BOD: 75 mg/L
SS: (unknown)
Influent Chamber
LEACHATE FROM LANDFILL
AERATION CELLS
NUMBER: (2) CELLS
DIMENSIONS:
54.9x74.7x2.5 m (CELL I)
63.4x100.6x2.6 m (CELL II)
VOLUME: 26680 m³ (total)
HRT: 1.6 days (design)
AERATION CAPACITY: 35 HP (SURFACE AERATOR)/CELL
ALUM Addition For Phosphorus Removal
LAGOONS
SYSTEM I
SYSTEM II
NUMBER: (3) (3)
SURF. AREA: 485620 m² (approx.)
VOLUME: 859200 m³ (total)
RET. TIME: 55 days (design)
S
S
Effluent Samplers
EFFLUENT TO SCUGOG RIVER VIA MARSH

## Table A.8

## HISTORICAL PERFORMANCE DATA (1988) OF LINDSAY STP

| Month | Average Flow ($m^3$/d) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 13980 | 121 | 106 | 8.1 | 6.6 | 6.1 | 0.7 |
| February | 12650 | 73 | 169 | 8.5 | 8.7 | 8.6 | 0.8 |
| March | 13760 | 82 | 123 | 6.4 | 11.3 | 9.8 | 0.7 |
| April | 16370 | 96 | 134 | 5.6 | 9.9 | 6.1 | 0.4 |
| May | 15510 | 69 | 100 | 5.2 | 10.9 | 17.1 | 1.1 |
| June | 11690 | 89 | 86 | 8.8 | 9.9 | 16.2 | 0.5 |
| July | 11420 | 177 | 48 | 5.4 | 11.8 | 16.3 | 0.7 |
| August | 12230 | 99 | 92 | 5.7 | 17.0 | 32.9 | 0.8 |
| September | 12590 | 61 | 45 | 4.7 | 5.8 | 7.8 | 0.9 |
| October | 12620 | 84 | 126 | 5.2 | 4.2 | 5.1 | 0.8 |
| November | 16550 | 59 | ND | 6.5 | 2.9 | ND | 0.6 |
| December | 13190 | 81 | 202 | 8.7 | 8.7 | 11.1 | 0.7 |
| Overall | 13550 | 90.9 | 112.8 | 6.5 | 9.0 | 12.5 | 0.7 |

ND = No Data

$BOD_5$, 12.5 mg/L suspended solids and 0.7 mg/L TP. The plant discharge complied with its effluent guidelines for $BOD_5$ and TSS for 1988; however, there was one excursion (May) above the monthly requirement of 1.0 mg/L TP.

### A.4.3 Industrial Contribution to Plant Influent

Based on a survey of industries in the catchment area, it is estimated that there are approximately 60 establishments representing 28 SICs. Major contributors to the municipal STP include a textile producer, a resin manufacturer, several plastics manufacturers, an asbestos manufacturer, two fabricated metal product plants and an electronics components manufacturer. The estimated industrial contribution to the Lindsay STP is approximately 25 percent of the total wastewater flow.

### A.4.4 Sampling Location

The parallel lagoon systems have separate discharge locations approximately 30 m apart. The flow split between the lagoons is unequal due to differences in the liquid levels. It was estimated that 40 percent of the flow goes to one lagoon system and 60 percent to the other. To obtain a representative effluent sample, separate composite samplers were located at each outfall. Equal volumes of effluent were collected from each outfall in separate refrigerated containers over 24 hours. Each 22-litre sample pail was then filled in proportion to the estimated flow through each lagoon system (40:60). Since electrical power was unavailable at the outfall location, a diesel generator was operated continuously to power the sampling equipment.

Grab samples collected at the Lindsay STP were similarly collected in proportion to the estimated flow through each lagoon system at the individual lagoon outfalls.

### A.4.5 Operating Conditions

The operating conditions at the Lindsay STP during the summer and winter sampling periods are summarized in Table A.9. The data presented in Table A.9 are based on monthly log sheets maintained by plant operating staff and routine samples submitted to MOE for analysis.

TABLE A.9: LINDSAY STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 9,265 | 10,400 |
| Percent of Design Flow | 54 | 61 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 93 | 63.5 |
| TSS (mg/L) | 114 | 117 |
| TP (mg/L) | 5.5 | - |
| Aerated Cell HRT (h) | 69.6 | 62.4 |
| Stabilization Pond HRT (d) | 93 | 83 |

Flows through the Lindsay plant during both periods were substantially lower than the 1988 average, representing between about 55 and 60 percent of the plant hydraulic capacity. These low flows produced HRTs in excess of 80 days in the stabilization ponds. During the winter sampling period, the lagoon cells were primarily ice-covered with open water evident only near the periphery. During the summer sampling period, significant algal growth was apparent in the lagoon cells. Raw wastewater strength was consistent with the historical data during both sampling periods.

## A.5 Midland STP

### A.5.1 Description of Facility

The Midland STP is a conventional activated sludge facility designed to handle 13,640 $m^3/d$ (3 MIGD) and discharging to Midland Bay on Lake Huron. A process flowsheet of the plant is shown in Figure A.5, along with key design parameters. The secondary section of the plant includes six mechanically-aerated cells; however, two of these are out-of-service as loading is below design. Sludges from the plant are anaerobically digested, dewatered and disposed to landfill due to high metal concentrations.

The plant disinfects by chlorinating in a three-pass contactor. Chlorination is only practised in the summer months from about 15 May to 1 November.

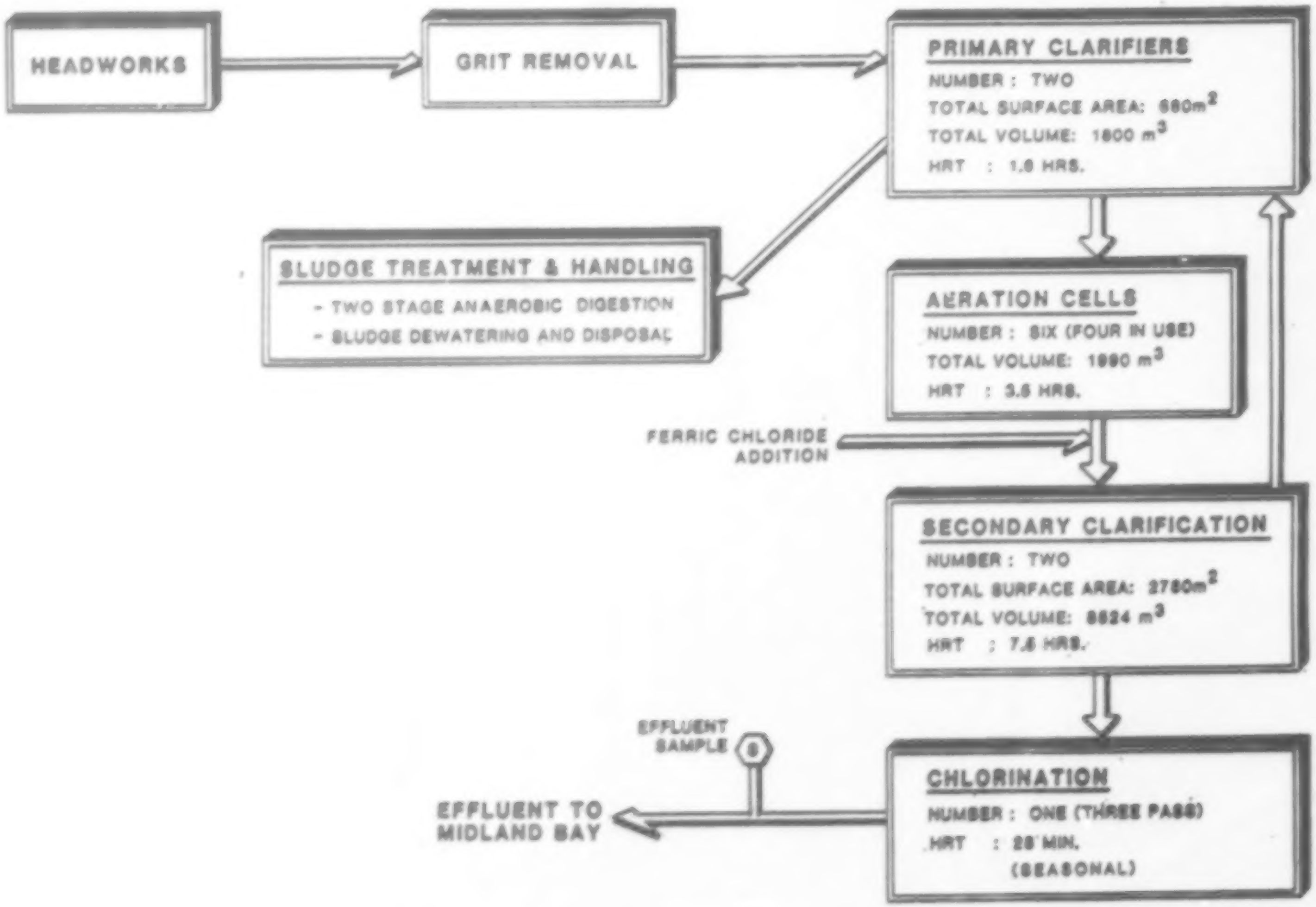
### A.5.2 Historical Performance

The historical performance of the Midland STP is summarized in Table A.10, based on 1988 operating results. During this period, the plant operated at approximately 83 percent of hydraulic capacity. The plant produced a consistently good quality effluent, averaging 3.8 mg/L $BOD_5$, 7.8 mg/L TSS and 0.6 mg/L TP and complying with all effluent guidelines.

### A.5.3 Industrial Contribution to Plant Influent

The Midland STP has a relatively high industrial flow contribution from metal finishing operations. Seven establishments in SIC 34 (metal finishing) operate in the catchment

FIGURE A.5: MIDLAND WPCP


HEADWORKS
GRIT REMOVAL
PRIMARY CLARIFIERS
NUMBER : TWO
TOTAL SURFACE AREA: 680m²
TOTAL VOLUME: 1800 m³
HRT : 1.6 HRS.
SLUDGE TREATMENT & HANDLING
- TWO STAGE ANAEROBIC DIGESTION
- SLUDGE DEWATERING AND DISPOSAL
AERATION CELLS
NUMBER : SIX (FOUR IN USE)
TOTAL VOLUME: 1990 m³
HRT : 3.5 HRS.
FERRIC CHLORIDE ADDITION
SECONDARY CLARIFICATION
NUMBER : TWO
TOTAL SURFACE AREA: 2780m²
TOTAL VOLUME: 8624 m³
HRT : 7.6 HRS.
CHLORINATION
NUMBER : ONE (THREE PASS)
HRT : 28 MIN.
(SEASONAL)
EFFLUENT SAMPLE
S
EFFLUENT TO MIDLAND BAY

DESIGN:
FLOW: 13638 $m^3$/d
BOD: 226 mg/L
SS: UNKNOWN

CH2M HILL

## Table A.10

## HISTORICAL PERFORMANCE DATA (1988)
## OF MIDLAND STP

| Month | Average Flow ($m^3$/d) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 10,940 | 60 | 165 | 6.6 | 4.2 | 6.6 | 0.5 |
| February | 10,680 | 83 | 153 | 7.3 | 5.0 | 10.1 | 1.0 |
| March | 11,890 | 49 | 120 | 4.3 | 4.0 | 8.3 | 0.6 |
| April | 11,870 | 57 | 101 | 4.9 | 4.1 | 6.8 | 0.5 |
| May | 11,580 | 54 | 165 | 6.3 | 3.7 | 8.8 | 0.6 |
| June | 11,130 | 66 | 183 | 5.8 | 2.4 | 7.3 | 0.9 |
| July | 10,170 | 112 | 200 | 5.1 | 5.9 | ND | 0.5 |
| August | 11,140 | 52 | 168 | 10.2 | 3.1 | ND | 0.7 |
| September | 11,380 | 65 | 157 | 3.7 | 3.5 | ND | 0.3 |
| October | 12,880 | 75 | 163 | 4.2 | 3.7 | 6.8 | 0.4 |
| November | 12,010 | 58 | 109 | 3.8 | 3.0 | 6.5 | 0.3 |
| December | 10,930 | 73 | 127 | 5.5 | 2.7 | 9.4 | 0.7 |
| Overall | 11,320 | 67.0 | 150.9 | 5.6 | 3.8 | 7.8 | 0.6 |

ND = No Data

area. Other major industrial dischargers include food industries (grain mills and bakeries), electronics manufacturers and machinery manufacturers. The estimated industrial flow contribution to the Midland treatment plant is approximately 40 percent of the total plant influent, most of which is contributed by a single metal finishing operation.

### A.5.4 Sampling Location

Composite and grab samples at the Midland STP were collected at the overflow of the chlorine contact chamber behind the overflow weir and at a depth of approximately 60 cm.

### A.5.5 Operating Conditions

The operating conditions at the Midland STP during the summer and winter sampling periods are summarized in Table A.11. The data in Table A.11 are based on the plant's routine operating log sheets and routine samples collected by plant staff and submitted to MOE for analysis.

Flows during the summer sampling period were at levels near the 1988 average, but were 15 percent lower during the winter sampling program. Waste strengths during both sampling periods were at historical levels. The organic loading averaged approximately 0.2 g BOD/g VSS.d. SRTs, estimated based on the aeration system F:M ratio, were approximately 7 days to 9 days.

## A.6 North Toronto STP

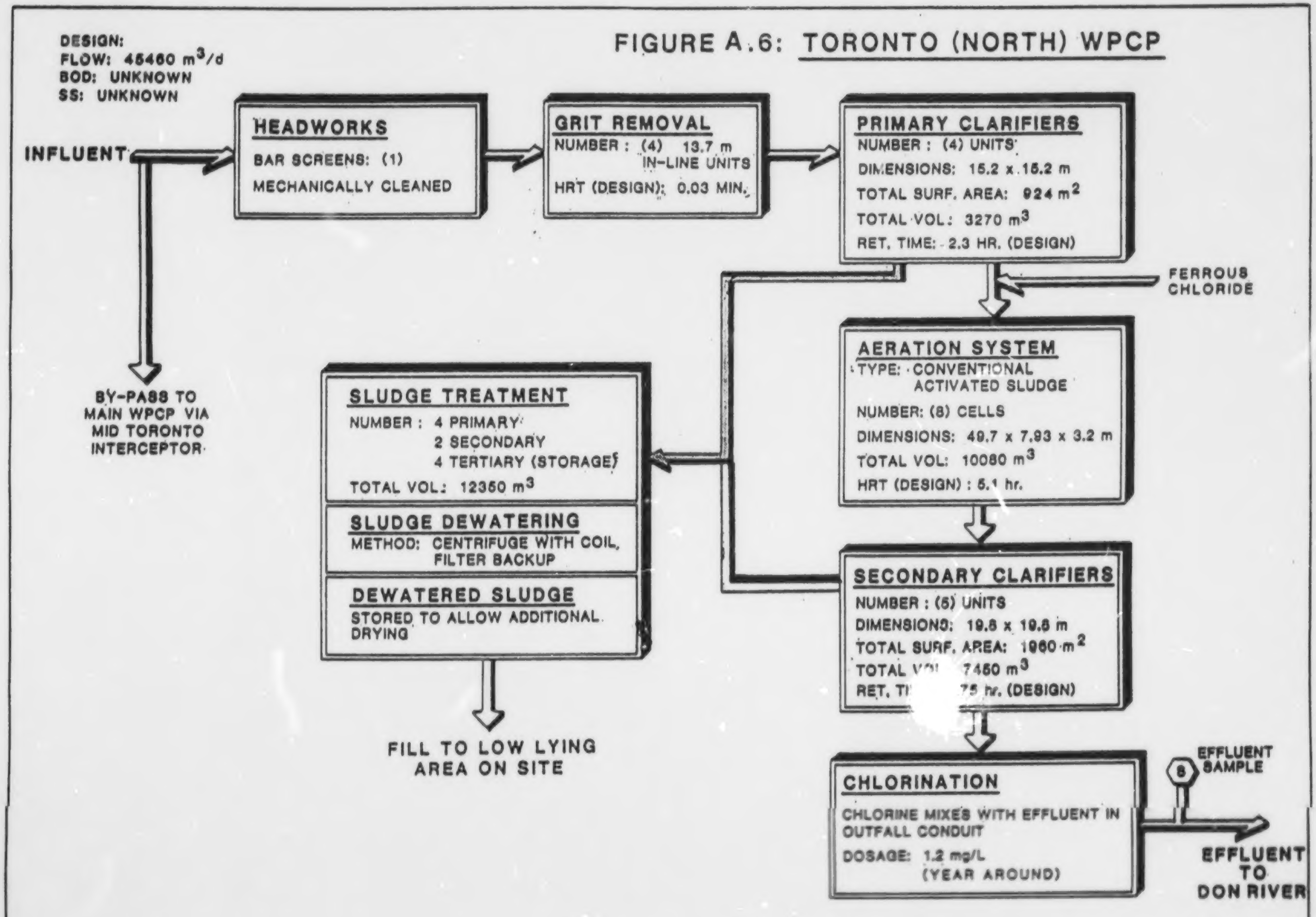
### A.6.1 Description of Facility

The North Toronto STP, illustrated schematically in Figure A.6, handles a relatively constant flow of about 35,000 $m^3/d$ from the mid-Toronto intercepter. The remaining flow is treated at the Main Treatment Plant. The North Toronto facility is a conventional activated sludge plant with a rated capacity of 45,460 $m^3/d$ (10 MIGD). Ferrous chloride is added to the secondary component of the plant for phosphorus removal. Sludges are anaerobically digested, dewatered, air dried and landfilled on site.

TABLE A.11: MIDLAND STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 11,170 | 9,480 |
| Percent of Design Flow | 82 | 69 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 80.0 | 76.7 |
| TSS (mg/L) | 149 | 165 |
| TP (mg/L) | 5.33 | 6.58 |
| Aeration Tank HRT (h) | 4.3 | 5.0 |
| SRT (d) | 7.2 | 9.0 |
| F:M Ratio ($d^{-1}$) | 0.22 | 0.18 |

FIGURE A.6: TORONTO (NORTH) WPCP


DESIGN:
FLOW: 45460 $m^3/d$
BOD: UNKNOWN
SS: UNKNOWN
INFLUENT
BY-PASS TO MAIN WPCP VIA MID TORONTO INTERCEPTOR
HEADWORKS
BAR SCREENS: (1)
MECHANICALLY CLEANED
GRIT REMOVAL
NUMBER : (4) 13.7 m IN-LINE UNITS
HRT (DESIGN): 0.03 MIN.
PRIMARY CLARIFIERS
NUMBER : (4) UNITS
DIMENSIONS: 15.2 x 15.2 m
TOTAL SURF. AREA: 924 $m^2$
TOTAL VOL: 3270 $m^3$
RET. TIME: 2.3 HR. (DESIGN)
FERROUS CHLORIDE
AERATION SYSTEM
TYPE: CONVENTIONAL ACTIVATED SLUDGE
NUMBER: (8) CELLS
DIMENSIONS: 49.7 x 7.93 x 3.2 m
TOTAL VOL: 10080 $m^3$
HRT (DESIGN) : 5.1 hr.
SECONDARY CLARIFIERS
NUMBER : (5) UNITS
DIMENSIONS: 19.8 x 19.8 m
TOTAL SURF. AREA: 1960 $m^2$
TOTAL V[illegible] 7450 $m^3$
RET. TI[illegible]75 hr. (DESIGN)
SLUDGE TREATMENT
NUMBER : 4 PRIMARY
2 SECONDARY
4 TERTIARY (STORAGE)
TOTAL VOL: 12350 $m^3$
SLUDGE DEWATERING
METHOD: CENTRIFUGE WITH COIL, FILTER BACKUP
DEWATERED SLUDGE
STORED TO ALLOW ADDITIONAL DRYING
FILL TO LOW LYING AREA ON SITE
CHLORINATION
CHLORINE MIXES WITH EFFLUENT IN OUTFALL CONDUIT
DOSAGE: 1.2 mg/L (YEAR AROUND)
8
EFFLUENT SAMPLE
EFFLUENT TO DON RIVER

Chlorination is practised year-round, with sodium hypochlorite addition to the outfall. The retention time in the outfall before discharge to the Don River provides for contact time for disinfection.

### A.6.2 Historical Performance

The performance of the North Toronto STP is summarized in Table A.12, based on 1988 operating records. The plant operated at approximately 35,000 $m^3$/d or 77 percent of rated capacity. Although in compliance with effluent BOD5 and TSS concentration guidelines on an annual basis, effluent concentrations for both parameters exceeded 25 mg/L in January, February and March. Effluent total phosphorus guidelines were exceeded in February and March. The plant has had problems with floating solids and scum on secondary clarifiers which contributed to the effluent quality problems in early 1988.

### A.6.3 Industrial Contribution to Plant Influent

An inventory of industries in the catchment area of the North Toronto STP indicates that approximately 90 industrial establishments are tributary to the facility. These establishments cover 28 SIC groups, but nearly half are in the printing and publishing sector. Machinery manufacturing establishments (SIC 35) and electronic/electrical component manufacturers (SIC 36) are other large sectors. Significant contributors include several chemical plants. Based on water use data, the estimated contribution of industrial discharges to the plant flow is approximately 10 percent.

### A.6.4 Sampling Location

Composite samples at the North Toronto STP were collected at a manhole on the plant outfall at a distance approximately 25 m downstream of the chlorine addition point. Sampler suction lines were located in a turbulent area of flow, at a submergence of about 15 cm.

### A.6.5 Operating Conditions

The operating conditions at the North Toronto STP during the summer and winter sampling periods are summarized in Table A.13. These operating parameters were

## Table A.12

## HISTORICAL PERFORMANCE DATA (1988) OF NORTH TORONTO STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 38,200 | 250 | 179 | 5.2 | 36.0 | 29.8 | 1.0 |
| February | 38,100 | 219 | 148 | 4.6 | 37.6 | 50.2 | 1.4 |
| March | 30,700 | 247 | 159 | 4.5 | 40.8 | 48.6 | 1.6 |
| April | 32,400 | 168 | 140 | 4.7 | 14.7 | 10.3 | 0.9 |
| May | 33,790 | 218 | 147 | 4.9 | 15.1 | 8.6 | 0.7 |
| June | 33,700 | 219 | 140 | 4.8 | 14.2 | 6.7 | 0.8 |
| July | 35,600 | 256 | 123 | 4.2 | 11.0 | 5.8 | 0.6 |
| August | 34,200 | 221 | 115 | 3.9 | 13.0 | 4.9 | 0.6 |
| September | 36,500 | 167 | 150 | 4.9 | 14.5 | 6.4 | 0.9 |
| October | 35,790 | 162 | 146 | 4.7 | 15.5 | 5.1 | 0.6 |
| November | 34,500 | 230 | 152 | 5.0 | 16.4 | 10.6 | 0.7 |
| December | 34,900 | 279 | 169 | 5.3 | 22.9 | 17.1 | 1.0 |
| Overall | 34,870 | 219.7 | 147.3 | 4.7 | 21.0 | 17.0 | 0.9 |

ND = No Data

## TABLE A.13: NORTH TORONTO STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 36,380 | 30,050 |
| Percent of Design Flow | 80 | 66 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 231.7 | 141.4 |
| TSS (mg/L) | 152.2 | 141.5 |
| TP (mg/L) | 5.22 | 4.67 |
| Aeration Tank HRT (h) | 6.7 | 8.1 |
| SRT (d) | 6.9 | 7.5 |
| F:M Ratio ($d^{-1}$) | 0.18 | 0.34 |

calculated based on the plant's routine monitoring log sheets and regular samples collected and analyzed by the operating authority.

Flows during both sampling periods were at near average levels. With the exception of the low organic strength during the winter sampling period, waste characteristics were also typical based on 1988 average data. During the winter sampling period, the plant had problems with floating scum on the aeration basins and secondary clarifiers. This contributed to high effluent suspended solids during this sampling. There was no evidence of these problems during the summer sampling. SRTs, calculated based on the plant's sludge wastage records during the period preceding the samplings, were approximately 7 days.

## A.7 Perth STP

### A.7.1 Description of Facility

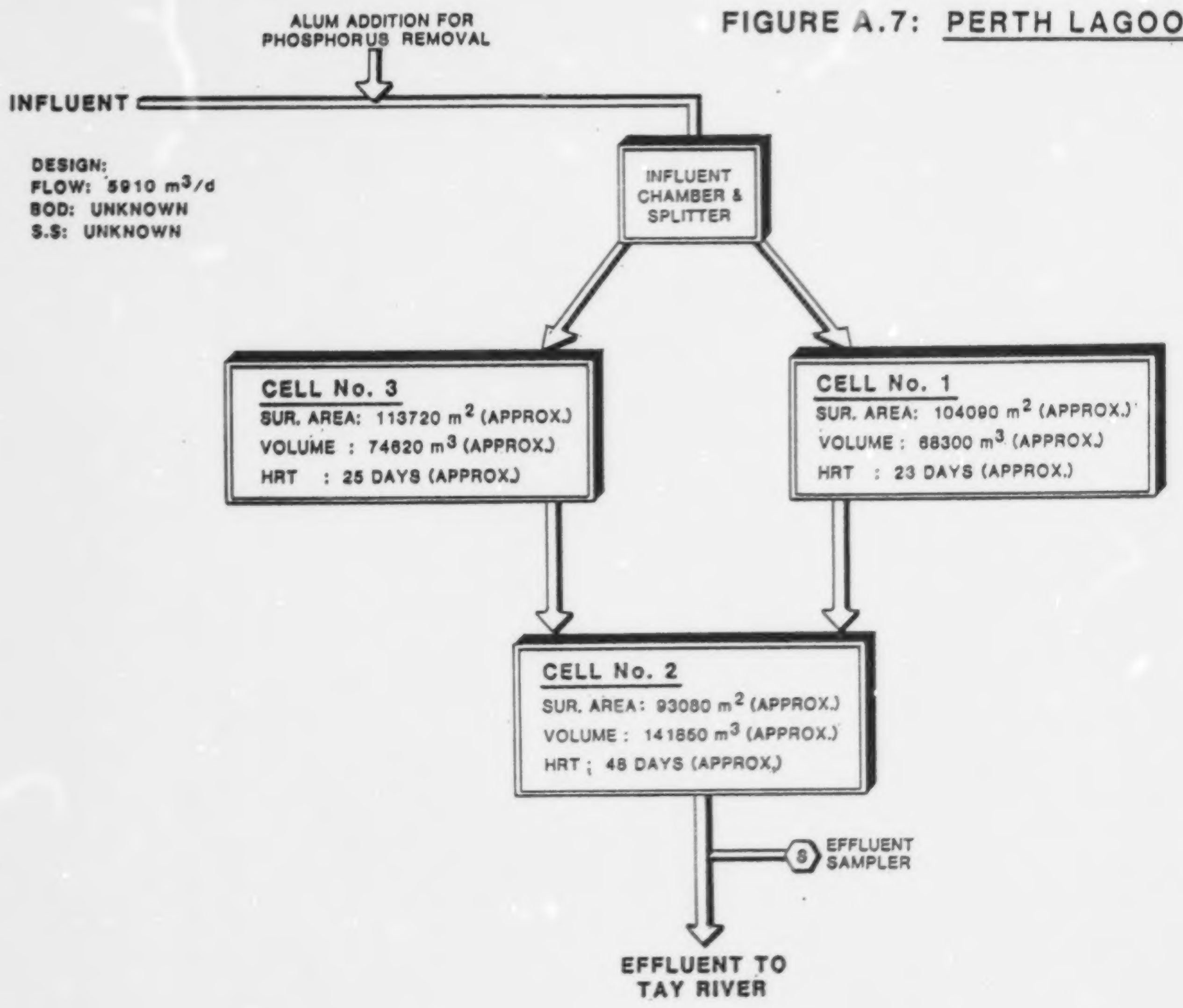
The Perth STP consists of conventional continuous discharge facultative lagoons with alum addition to the raw sewage for phosphorus removal. The design capacity of the facility is 5,910 $m^3/d$ (1.3 MIGD). As illustrated schematically in Figure A.7, the influent flow is split between two lagoon cells in series, each providing about 24 days of hydraulic retention time. The combined discharges of these lagoons enter the final pond prior to discharge to the Tay River.

Final effluent chlorination is not practised at the Perth STP.

### A.7.2 Historical Performance

The performance of the Perth STP is summarized in Table A.14 based on 1988 operating records. During that period, flow to the facility averaged approximately 6,110 $m^3/d$ or slightly more than the rated capacity of the plant. Despite the high flow relative to design, the facility complied with effluent quality guidelines in 1988, averaging approximately 15 mg/L $BOD_5$, 15 mg/L TSS and 0.5 mg/L TP.

FIGURE A.7: PERTH LAGOONS


ALUM ADDITION FOR PHOSPHORUS REMOVAL
INFLUENT
DESIGN:
FLOW: 5910 m³/d
BOD: UNKNOWN
S.S: UNKNOWN
INFLUENT CHAMBER & SPLITTER
CELL No. 3
SUR. AREA: 113720 m² (APPROX.)
VOLUME : 74620 m³ (APPROX.)
HRT : 25 DAYS (APPROX.)
CELL No. 1
SUR. AREA: 104090 m² (APPROX.)
VOLUME : 68300 m³ (APPROX.)
HRT : 23 DAYS (APPROX.)
CELL No. 2
SUR. AREA: 93080 m² (APPROX.)
VOLUME : 141850 m³ (APPROX.)
HRT ; 48 DAYS (APPROX.)
S
EFFLUENT SAMPLER
EFFLUENT TO TAY RIVER

CH2M HILL

## Table A.14

## HISTORICAL PERFORMANCE DATA (1988) OF PERTH STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) BOD$_5$ | TSS | TP | Effluent Quality (mg/L) BOD$_5$ | TSS | TP |
|---|---|---|---|---|---|---|---|
| January | ND | 92 | 188 | 2.4 | 12.0 | 26.0 | 0.7 |
| February | 4360 | ND | 64 | 2.4 | ND | 20.0 | 0.6 |
| March | 9380 | 80 | 90 | 2.8 | 35.0 | 30.0 | 1.0 |
| April | 8960 | 68 | 56 | 2.4 | 13.0 | 14.0 | 0.3 |
| May | 9560 | 195 | 261 | 5.0 | 1.6 | 1.7 | 0.3 |
| June | 4400 | 125 | 84 | 2.5 | 25.0 | 22.0 | 0.5 |
| July | 2980 | 100 | 71 | 7.0 | 36.0 | 20.0 | 0.2 |
| August | 4380 | ND | 118 | 4.0 | ND | 12.0 | 0.3 |
| September | 4660 | 46 | 72 | 2.4 | 1.4 | 3.0 | 0.7 |
| October | 5530 | 46 | 60 | 1.7 | 6.0 | 11.0 | 0.5 |
| November | 8150 | 42 | 79 | 1.8 | 14.0 | 11.0 | 0.2 |
| December | 4790 | 140 | 125 | 3.9 | 5.0 | 8.0 | 0.5 |
| Overall | 6110 | 93.4 | 105.7 | 3.2 | 14.9 | 14.9 | 0.5 |

ND = No Data

### A.7.3 Industrial Contribution to Plant Influent

There are about 30 smaller industrial and commercial establishments tributary to the Perth STP, including several metal finishers and metal fabricators, chemical industries and textile plants. No estimate of the flow contribution to the plant from these establishments is available, although town staff suggest that it is small.

### A.7.4 Sampling Location

Grab and composite samples of final effluent were collected at the outfall of the final lagoon to the Tay River. As no electrical power was available at the outfall, a gasoline-fuelled generator was operated continuously to provide power to the sampling equipment.

### A.7.5 Operating Conditions

The operating conditions at the Perth STP during the summer and winter sampling periods are summarized in Table A.15. These data are based on monthly operating log sheets and routine samples submitted to MOE for analysis.

Flows to the Perth STP were substantially lower than the historical 1988 average during both sampling periods, resulting in longer than design HRTs in the stabilization ponds. However, the organic strength of the wastewater was high compared to the historical average. As was the case at the Lindsay STP, the ponds were essentially ice-covered during the winter sampling period. Algal growth was evident during the summer sampling period.

## A.8 Stratford STP

### A.8.1 Description of Facility

The Stratford STP is a 27,300 $m^3$/d (6.0 MIGD) conventional activated sludge plant with final effluent polishing in dual media filters. Two primary clarifiers are utilized as dedicated stormwater tanks. Ferrous chloride is added to the triple-pass aeration tanks for phosphorus removal. All flows up to approximately 36,000 $m^3$/d (8.0 MIGD) receive full tertiary treatment. At flows in excess of 36,000 $m^3$/d, the final filters are bypassed

### TABLE A.15: PERTH STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 4,139 | 5,249 |
| Percent of Design Flow | 70 | 89 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 152.5 | 158 |
| TSS (mg/L) | 182.4 | 84 |
| TP (mg/L) | 3.65 | 2.7 |
| Stabilization Pond HRT (d) | 70 | 53 |

and chlorinated secondary effluent is discharged to the Avon River. Chlorine is added upstream of the filters on a year-round basis. The facility is shown schematically in Figure A.8. Key design parameters are included in Figure A.8.

### A.8.2 Historical Performance

The performance of the Stratford STP is summarized in Table A.16, based on 1988 performance records. During this period, average plant flow was approximately 22,000 $m^3/d$, equivalent to 80 percent of design. The plant produced a consistently high quality effluent throughout 1988, averaging 9.4 mg/L $BOD_5$, 1.8 mg/L TSS and 0.3 mg/L TP, despite periods of high flow during spring and fall months.

### A.8.3 Industrial Contribution to Plant Influent

The industrial flow contribution to the Stratford STP is not well defined. Approximately 60 industrial establishments have been identified in the catchment area, representing 15 SIC groups. The major sectors represented include machinery manufacturing, fabricated metal products and electrical/electronic component manufacturers. No data on water use or wastewater discharge volumes are available.

### A.8.4 Sampling Location

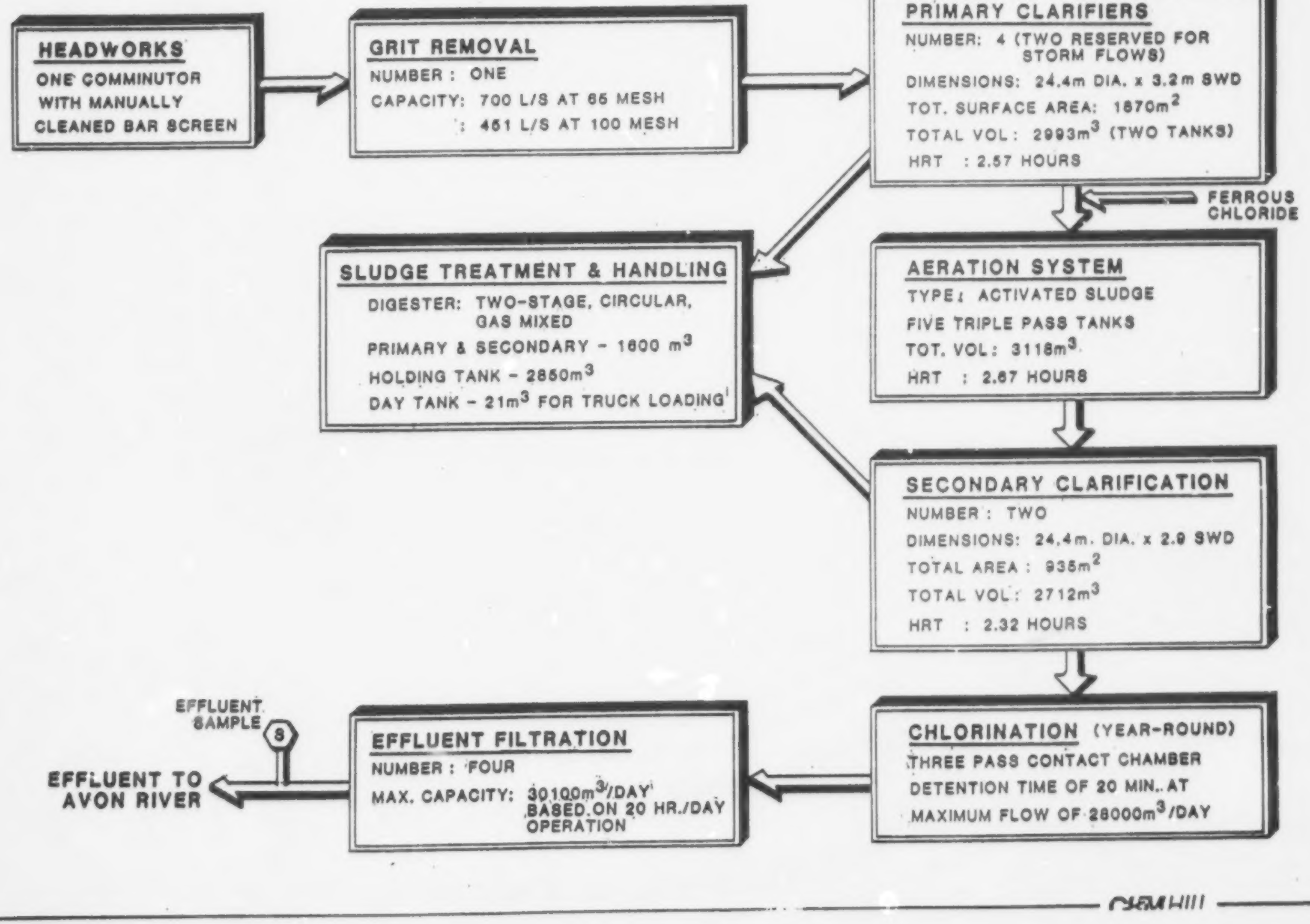
The composite final effluent samples at the Stratford STP were collected from the filtered effluent clearwell. Plant flow did not exceed the 36,000 $m^3/d$ limit on the tertiary filters which would have necessitated bypassing the filters. There is no discharge from the Stratford STP during backwashing of the final filters. This occurs daily for a period of about 30 minutes. During this time period, the composite samples were transferred from the refrigerated containers to the 22-L sample pails.

### A.8.5 Operating Conditions

The operating conditions at the Stratford STP during the summer and winter sampling periods are summarized in Table A.17. These data are based on the plant's routine monitoring log sheets and samples submitted regularly to MOE for analysis.

## FIGURE A.8: STRATFORD WPCP

DESIGN:
FLOW: 27300m$^3$/d
BOD: 140 mg/L
SS: 250 mg/L


HEADWORKS
ONE COMMINUTOR
WITH MANUALLY
CLEANED BAR SCREEN
GRIT REMOVAL
NUMBER : ONE
CAPACITY: 700 L/S AT 65 MESH
: 451 L/S AT 100 MESH
PRIMARY CLARIFIERS
NUMBER: 4 (TWO RESERVED FOR STORM FLOWS)
DIMENSIONS: 24.4m DIA. x 3.2m SWD
TOT. SURFACE AREA: 1870m²
TOTAL VOL: 2993m³ (TWO TANKS)
HRT : 2.57 HOURS
FERROUS CHLORIDE
AERATION SYSTEM
TYPE: ACTIVATED SLUDGE
FIVE TRIPLE PASS TANKS
TOT. VOL: 3118m³
HRT : 2.67 HOURS
SLUDGE TREATMENT & HANDLING
DIGESTER: TWO-STAGE, CIRCULAR, GAS MIXED
PRIMARY & SECONDARY - 1600 m³
HOLDING TANK - 2850m³
DAY TANK - 21m³ FOR TRUCK LOADING
SECONDARY CLARIFICATION
NUMBER : TWO
DIMENSIONS: 24.4m. DIA. x 2.9 SWD
TOTAL AREA : 935m²
TOTAL VOL: 2712m³
HRT : 2.32 HOURS
CHLORINATION (YEAR-ROUND)
THREE PASS CONTACT CHAMBER
DETENTION TIME OF 20 MIN. AT
MAXIMUM FLOW OF 28000m³/DAY
EFFLUENT FILTRATION
NUMBER : FOUR
MAX. CAPACITY: 30100m³/DAY BASED ON 20 HR./DAY OPERATION
EFFLUENT SAMPLE
S
EFFLUENT TO AVON RIVER

## Table A.16

## HISTORICAL PERFORMANCE DATA (1988)
## OF STRATFORD STP

| Month | Average Flow ($m^3$/d) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 19850 | 134 | 121 | 5.2 | 14.1 | 1.5 | 0.3 |
| February | 20960 | 142 | 174 | 5.6 | 4.0 | 0.7 | 0.5 |
| March | 29220 | 80 | 113 | 3.8 | 4.8 | 0.7 | 0.5 |
| April | 25030 | 71 | 48 | 3.3 | 4.9 | 0.7 | 0.3 |
| May | 21320 | 112 | 100 | 2.6 | 5.3 | 1.8 | 0.2 |
| June | 17700 | 90 | 122 | 5.6 | 12.9 | 7.3 | 0.2 |
| July | 18040 | 88 | 108 | 5.3 | 8.7 | 1.5 | 0.1 |
| August | 17270 | 112 | 108 | 3.9 | 13.1 | 2.4 | 0.3 |
| September | 18770 | 95 | 139 | 5.6 | 18.6 | 0.9 | 0.1 |
| October | 24750 | 69 | 77 | 4.9 | 8.5 | 1.8 | 0.1 |
| November | 29360 | 35 | 39 | 2.6 | 9.8 | 1.5 | 0.1 |
| December | 22490 | 85 | 108 | 5.8 | 7.5 | 1.3 | 0.5 |
| Overall | 22060 | 92.8 | 104.8 | 4.5 | 9.4 | 1.8 | 0.3 |

ND = No Data

## TABLE A.17: STRATFORD STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 18,140 | 30,160 |
| Percent of Design Flow | 65 | 108 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 76.1 | 62.5 |
| TSS (mg/L) | 96.8 | 108.1 |
| TP (mg/L) | 5.0 | 4.2 |
| Aeration Tank HRT (h) | 4.1 | 2.5 |
| SRT (d) | 3.6 | 3.2 |
| F:M Ratio ($d^{-1}$) | 0.22 | 0.58 |

Flows and waste characteristics during the summer sampling period were at near historic levels. During the winter, high flows were experienced. The average flow immediately prior to the week of sampling was in excess of the plant hydraulic capacity. Waste strength, in terms of organics, was somewhat lower during this period. Due to the high flows experienced during the winter, HRT in the aeration section of the plant was only 2.5 hours. Based on plant records of sludge wastage, the SRT during both sampling periods was about 3 days, although the organic loading was substantially higher during the winter period.

## A.9 Walkerton STP

### A.9.1 Description of Facility

The Walkerton STP is a conventional activated sludge plant designed to treat 7,540 $m^3$/d (1.66 MIGD) prior to discharge to the Saugeen River. The plant is shown schematically in Figure A.9 and key process design criteria are included in the process flow sheet. Oxygen transfer in the aeration cells is supplemented with floating-aerators to handle the organic load from a food processor (see Section A.9.3). Ferric chloride is added to the secondary clarifiers for phosphorus removal and also to the grit tank to improve primary clarifier performance.

Chlorination is practised seasonally from May 15 to September 15. Two parallel chlorine contactors are available, although only one is in service at any time.

### A.9.2 Historical Performance

The performance of the Walkerton STP in 1988 is summarized in Table A.18. Average flow during this period was 4,740 $m^3$/d, only 63 percent of design capacity. The plant performed well throughout 1988, producing a final effluent containing 9.3 mg/L $BOD_5$, 7.2 mg/L TSS and 0.8 mg/L TP despite high influent concentrations. The facility was in compliance with all effluent quality guidelines.

### A.9.3 Industrial Contribution to Plant Influent

The Walkerton STP receives a major fraction of its flow and organic loading from a poultry processing operation. Plant staff estimate that between 25 and 30 percent of the

FIGURE A.9: WALKERTON WPCP

DESIGN:
FLOW: 7560 $m^3$/d
BOD: 265 mg/L
SS: 206 mg/L.

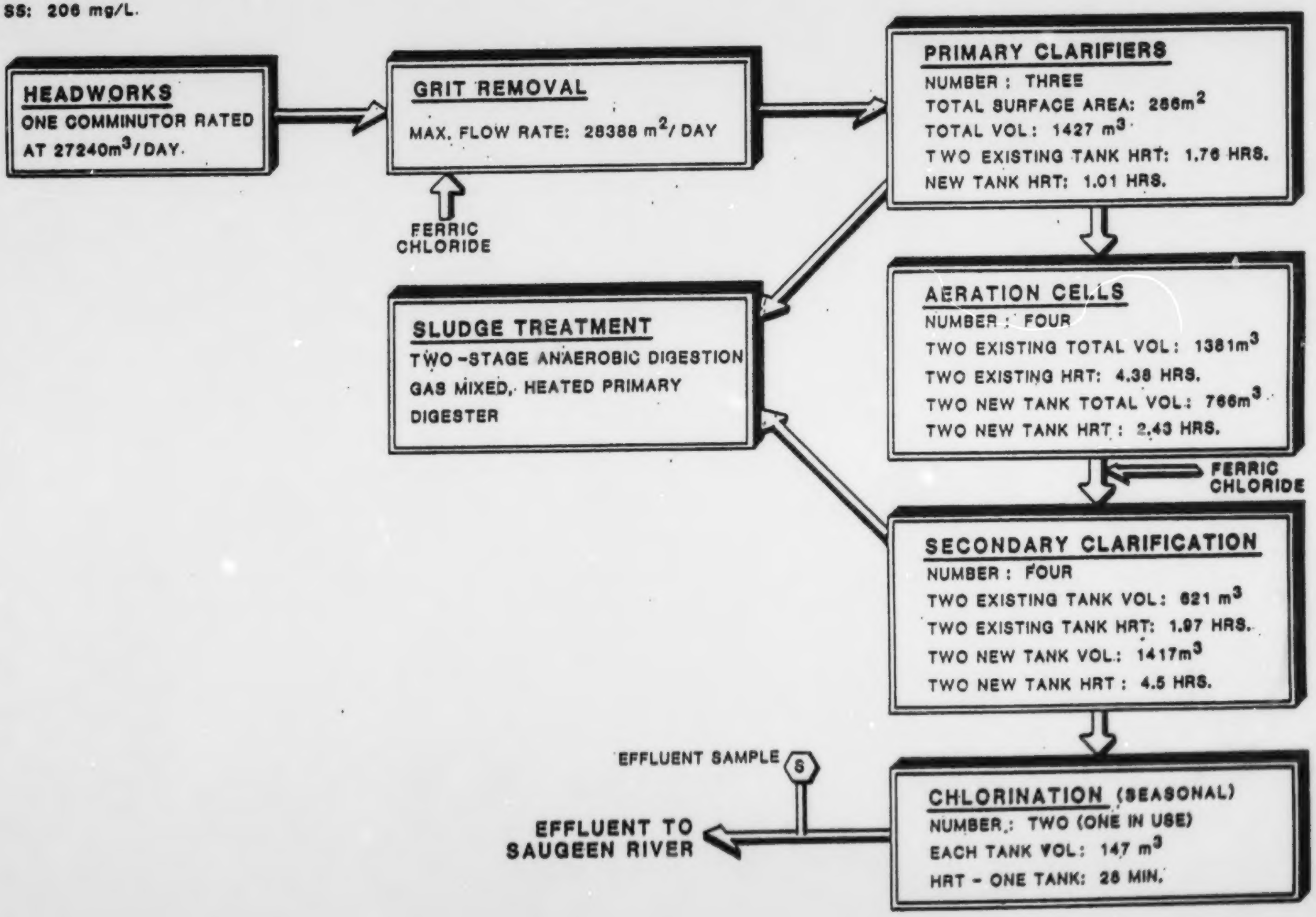

HEADWORKS
ONE COMMINUTOR RATED AT 27240m³/DAY.
GRIT REMOVAL
MAX. FLOW RATE: 28388 m²/ DAY
FERRIC CHLORIDE
PRIMARY CLARIFIERS
NUMBER : THREE
TOTAL SURFACE AREA: 286m²
TOTAL VOL: 1427 m³
TWO EXISTING TANK HRT: 1.76 HRS.
NEW TANK HRT: 1.01 HRS.
SLUDGE TREATMENT
TWO-STAGE ANAEROBIC DIGESTION
GAS MIXED, HEATED PRIMARY DIGESTER
AERATION CELLS
NUMBER : FOUR
TWO EXISTING TOTAL VOL: 1381m³
TWO EXISTING HRT: 4.38 HRS.
TWO NEW TANK TOTAL VOL: 766m³
TWO NEW TANK HRT : 2.43 HRS.
FERRIC CHLORIDE
SECONDARY CLARIFICATION
NUMBER : FOUR
TWO EXISTING TANK VOL: 621 m³
TWO EXISTING TANK HRT: 1.97 HRS.
TWO NEW TANK VOL: 1417m³
TWO NEW TANK HRT : 4.5 HRS.
EFFLUENT SAMPLE
S
CHLORINATION (SEASONAL)
NUMBER : TWO (ONE IN USE)
EACH TANK VOL: 147 m³
HRT - ONE TANK: 28 MIN.
EFFLUENT TO SAUGEEN RIVER

Table A.18

## HISTORICAL PERFORMANCE DATA (1988) OF WALKERTON STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) $BOD_5$ | TSS | TP | Effluent Quality (mg/L) $BOD_5$ | TSS | TP |
|---|---|---|---|---|---|---|---|
| January | 5,480 | 219 | 163 | 6.0 | 6.9 | 4.7 | 0.8 |
| February | 5,810 | 212 | 186 | 5.3 | 9.9 | 9.6 | 0.8 |
| March | 6,850 | 195 | 139 | 5.2 | 10.4 | 5.2 | 0.9 |
| April | 6,280 | 148 | 99 | 4.5 | 14.0 | 10.2 | 0.9 |
| May | 4,940 | 241 | 129 | 5.8 | 12.5 | 4.8 | 0.5 |
| June | 4,320 | 354 | 316 | 6.9 | 12.0 | 10.6 | 1.0 |
| July | 2,730 | 128 | 68 | 4.4 | 1.5 | 3.6 | 0.3 |
| August | 2,710 | 49 | 87 | 4.6 | 5.0 | 6.4 | 0.8 |
| September | 3,480 | 209 | 187 | 5.0 | 10.2 | 6.5 | 0.9 |
| October | 4,660 | 230 | 244 | 6.2 | 7.3 | 7.2 | 1.0 |
| November | 5,180 | 282 | 209 | 7.0 | 11.3 | 7.0 | 1.0 |
| December | 4,390 | 180 | 165 | 6.4 | 11.0 | 10.9 | 0.8 |
| Overall | 4,740 | 203.9 | 166.0 | 5.6 | 9.3 | 7.2 | 0.8 |

ND = No Data

total plant flow originates from this source. Other industrial contributors include a battery manufacturer and a metal finisher, although no estimate of flow from these sources is available. The local hospital laundry is also a major source of flow to the facility.

### A.9.4 Sampling Location

The final effluent was sampled at the overflow weir of the chlorine contactor at a depth of approximately 60 cm. Only one contactor was in use during the sampling period.

### A.9.5 Operating Conditions

The operating conditions at the Walkerton STP during the summer and winter sampling periods are summarized in Table A.19. These data are based on the plant's routine monitoring sheets and samples submitted to MOE for analysis.

Flows to the plant were higher than the historic 1988 levels, particularly during the winter sampling period when they averaged near 85 percent of the plant design capacity. Waste strengths were at near historic concentration levels during both sampling periods however. Aeration tank HRTs were in the 8 to 9 hour range. Based on plant records of sludge wastage from the system, the SRT was in the 10 to 12 day range during both sampling periods. The organic loading ranged from 0.14 to 0.22 g BOD/g VSS.d.

## A.10 Wallaceburg STP

### A.10.1 Description of Facility

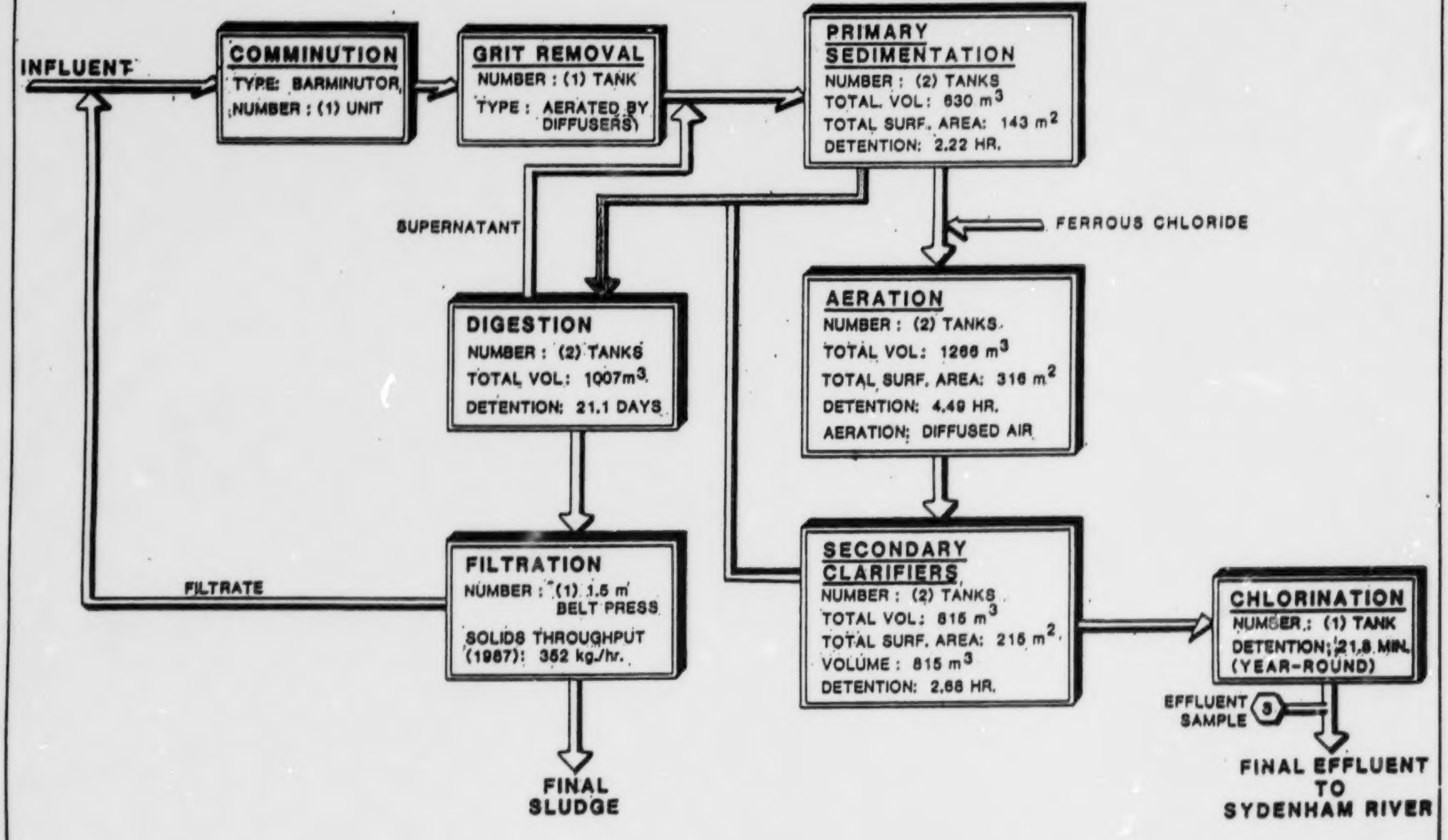
The Wallaceburg STP is a conventional activated sludge plant with a design hydraulic capacity of 6,820 $m^3$/d (1.5 MIGD). Ferrous chloride is added to the aeration tanks for phosphorus removal. Chlorination is practised year-round prior to discharge of the final effluent to the Sydenham River. Sludges from the plant are digested, dewatered on a belt press and air-dried. Final disposal is to the municipal landfill due to elevated metal concentrations. The plant is shown schematically in Figure A.10, along with key design criteria.

TABLE A.19: WALKERTON STP OPERATING CONDITIONS

| | Operating Conditions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 5,340 | 6,430 |
| Percent of Design Flow | 71 | 85 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 249 | 222 |
| TSS (mg/L) | 156 | 172 |
| TP (mg/L) | 6.40 | 6.27 |
| Aeration Tank HRT (h) | 9.4 | 7.8 |
| SRT (d) | 12.4 | 10.2 |
| F:M Ratio ($d^{-1}$) | 0.14 | 0.22 |

# FIGURE A.10: WALLACEBURG WPCP

DESIGN:
FLOW: 6.819 x 103m$^3$/d
BOD: 200 mg/L
SS: 250 mg/L


INFLUENT
COMMINUTION
TYPE: BARMINUTOR
NUMBER : (1) UNIT
GRIT REMOVAL
NUMBER : (1) TANK
TYPE : AERATED BY DIFFUSERS)
PRIMARY SEDIMENTATION
NUMBER : (2) TANKS
TOTAL VOL: 630 m3
TOTAL SURF. AREA: 143 m2
DETENTION: 2.22 HR.
SUPERNATANT
FERROUS CHLORIDE
DIGESTION
NUMBER : (2) TANKS
TOTAL VOL: 1007m3
DETENTION: 21.1 DAYS
AERATION
NUMBER : (2) TANKS
TOTAL VOL: 1266 m3
TOTAL SURF. AREA: 316 m2
DETENTION: 4.49 HR.
AERATION: DIFFUSED AIR
FILTRATE
FILTRATION
NUMBER : (1) 1.5 m BELT PRESS
SOLIDS THROUGHPUT (1987): 352 kg./hr.
SECONDARY CLARIFIERS
NUMBER : (2) TANKS
TOTAL VOL: 815 m3
TOTAL SURF. AREA: 216 m2
VOLUME : 815 m3
DETENTION: 2.66 HR.
CHLORINATION
NUMBER : (1) TANK
DETENTION: 21.8 MIN.
(YEAR-ROUND)
EFFLUENT SAMPLE
3
FINAL SLUDGE
FINAL EFFLUENT TO SYDENHAM RIVER

CH2M HILL

### A.10.2 Historical Performance

The 1988 performance of the Wallaceburg STP is summarized in Table A.20. Average flow for 1988 was 6,120 $m^3/d$, equivalent to approximately 90 percent of design capacity. Effluent quality was generally good throughout 1988, averaging 8.7 mg/L $BOD_5$, 9.0 mg/L TSS and 0.5 mg/L TP. However, there was one month (February) of non-compliance with the effluent TP guideline.

### A.10.3 Industrial Contributors to Plant Influent

The Wallaceburg STP serves a highly industrialized catchment area. The total contribution of industrial flow to the plant may be as high as 40 percent of the total plant flow. Of the approximately 50 industries tributary to the plant, major contributors include metal finishing and electroplating operations, a foundry and machinery and transportation equipment manufacturers.

### A.10.4 Sampling Locations

Composite and grab samples of final effluent from the Wallaceburg STP were collected behind the overflow weir of the chlorine contact chamber, 60 cm below the liquid surface.

### A.10.5 Operating Conditions

The operating conditions at the Wallaceburg STP during the summer and winter sampling periods are summarized in Table A.21. These data are based on the plant's routine monitoring sheets and samples submitted to MOE for analysis.

Flows to the facility were at typical levels during the summer sampling period but were very high during the winter sampling period, averaging 126 percent of hydraulic capacity, due to several rainfall events. The raw wastewater during the winter period was more dilute in terms of organic strength (BOD) and phosphorus, but substantially more concentrated in terms of suspended solids content. The organic loading during both periods was similar, however. Based on plant operating records of sludge wastage, the SRTs during both periods were approximately 4 days.

## Table A.20

## HISTORICAL PERFORMANCE DATA (1988) OF WALLACEBURG STP

| Month | Average Flow ($m^3/d$) | Influent Quality (mg/L) | | | Effluent Quality (mg/L) | | |
|---|---|---|---|---|---|---|---|
| | | $BOD_5$ | TSS | TP | $BOD_5$ | TSS | TP |
| January | 6840 | 123 | 168 | 9.1 | 12.0 | 9.0 | 0.9 |
| February | 7110 | 100 | 192 | 12.1 | 9.0 | 11.0 | 1.1 |
| March | 7540 | 102 | 183 | 7.2 | 13.0 | 10.0 | 0.6 |
| April | 7270 | 71 | 195 | 5.3 | 8.0 | 9.0 | 0.4 |
| May | 6540 | 108 | 244 | 6.8 | 8.0 | 9.0 | 0.2 |
| June | 6390 | 133 | 266 | 6.2 | 14.3 | 11.0 | 0.3 |
| July | 5810 | 86 | 238 | 6.7 | 8.8 | 9.0 | 0.3 |
| August | 5270 | 98 | 216 | 6.0 | 6.6 | 6.3 | 0.3 |
| September | 4460 | 121 | 255 | 4.3 | 4.0 | 9.3 | 0.4 |
| October | 4670 | 124 | 241 | 4.5 | 6.8 | 8.8 | 0.4 |
| November | 6320 | 94 | 242 | 4.1 | 6.0 | 7.5 | 0.3 |
| December | 5260 | 98 | 204 | 10.8 | 7.7 | 8.6 | 0.9 |
| Overall | 6120 | 104.8 | 220.3 | 6.9 | 8.7 | 9.0 | 0.5 |

ND = No Data

## TABLE A.21: WALLACEBURG STP OPERATING CONDITIONS

| | Operating Conditiions | |
|---|---|---|
| | Summer Sampling | Winter Sampling |
| Average Flow ($m^3/d$) | 6,126 | 8,590 |
| Percent of Design Flow | 90 | 126 |
| Raw Sewage Quality | | |
| $BOD_5$ (mg/L) | 102.2 | 84.1 |
| TSS (mg/L) | 129.0 | 336.8 |
| TP (mg/L) | 5.40 | 4.63 |
| Aeration Tank HRT (h) | 5.0 | 3.5 |
| SRT (d) | 4.0 | 4.3 |
| F:M Ratio ($d^{-1}$) | 0.26 | 0.30 |

# APPENDIX B

## Toxicity Test Methods

## APPENDIX B: TOXICITY TEST METHODS

### B.1 Rainbow Trout Lethality

#### Holding Conditions

Rainbow trout (Oncorhynchus mykiss, formerly Salmo gairdneri) were obtained from Rainbow Springs Hatchery, Thamesford, Ontario, as certified disease-free according to Schedule B of the Fish Health Protection Regulations under the Fisheries Act of Canada. Fish were acclimated to dechlorinated Brampton tap water (Table B.1, at 15±2°C) ten days prior to testing. Background mortality of fish stocks was less than 0.1% during the two-week acclimation period. Fish were held under a 12-hour light, 12-hour dark photoperiod and fed a commercial trout chow at the rate of 2 to 3% of the total stock biomass daily.

#### Test Conditions

The tests were performed according to the protocol developed by the OMOE (1983b). Twenty litres of test solution at 15±1°C were prepared in concentrations of 100, 70, 50, 30, 20 and 10%, and ten fish were introduced into each concentration vessel. Temperature and photoperiod were identical to holding conditions (12 hours light/12 hours darkness). Fish were not fed and test solutions were not renewed. A minimum fish loading rate of 0.5 L of test solutions/g of fish/day was maintained throughout the exposure period. Six plastic containers, each containing ten fish in 20 L of solution, were held at a constant temperature of 15±1°C. A photoperiod of 12 hours light/12 hours darkness was maintained during testing. The tests were accompanied by a control in which the fish were exposed to dechlorinated Brampton tap water (Table B.1) under the same test conditions. Dissolved oxygen, pH, conductivity, temperature and fish survival were monitored daily in each test container. The specific details of the bioassays conducted are shown in Table B.2.

Sample LC50s were calculated using standard estimation techniques available in the form of a computer program developed by C.E. Stephan, U.S. EPA, Duluth, MN. The moving average method was usually selected when the data included concentrations which caused

## TABLE B.1: DILUTION WATER CHEMISTRY

| Parameter | Mean | Standard Deviation |
|---|---|---|
| **Inorganics (mg/L)** | | |
| Alkalinity (as $CaCO_3$, 25°C) | 99 | 5.5 |
| Aluminum | 0.10 | 0.02 |
| Ammonia-Nitrogen | 0.06 | 0.05 |
| Antimony | LT 0.002 | |
| Arsenic | LT 0.001 | |
| Barium | 0.02 | 0.0 |
| Beryllium | LT 0.01 | |
| Bromide | LT 0.05 | |
| Cadmium | LT 0.005 | |
| Calcium | 40 | 2.2 |
| Chloride | 32 | 5.0 |
| Chlorine, Total Residual | LT 0.05 | |
| Chromium | LT 0.01 | |
| Cobalt | LT 0.01 | |
| Conductivity (umhos, 25°C) | 376 | 15.2 |
| Copper | 0.007 | 0.003 |
| Dissolved Oxygen (25°C) | 7.9 | 0.49 |
| Fluoride | 0.94 | 0.025 |
| Hardness (as $CaCO_3$, 25°C) | 150 | 4.9 |
| Iron | LT 0.02 | |
| Lead | LT 0.05 | |
| Magnesium | 8.3 | 0.31 |
| Manganese | LT 0.01 | |
| Mercury | LT 0.00005 | |
| Molybdenum | LT 0.02 | |
| Nickel | LT 0.01 | |
| Nitrate-Nitrogen | 0.51 | 0.043 |
| Nitrite-Nitrogen | LT 0.04 | |
| pH (25°C) | 8.27 | 0.065 |
| Potassium | 1.98 | 0.356 |
| Sodium | 15.4 | 2.17 |
| Strontium | 0.19 | 0.011 |
| Sulphate | 34 | 1.9 |
| Vanadium | LT 0.01 | |
| Zinc | LT 0.01 | |

TABLE B.1: DILUTION WATER CHEMISTRY (Cont'd)

| Parameter | Mean | Standard Deviation |
|---|---|---|
| **Organics (ug/L)*** | | |
| Aldrin | LT 0.07 | |
| g-BHC | LT 4 | |
| Carbaryl | LT 70 | |
| Total Chlordane | LT 7 | |
| Total DDT | LT 30 | |
| Diazinon | LT 14 | |
| Dieldrin | LT 0.7 | |
| Endrin | LT 0.2 | |
| Heptachlor Epoxide | LT 3 | |
| Heptachlor | LT 3 | |
| Methoxychlor | LT 100 | |
| Methyl Parathion | LT 7 | |
| Parathion | LT 35 | |
| Total PCB | LT 3 | |
| Toxaphene | LT 5 | |

LT = Less than.

TABLE B.2: CONDITIONS OF RAINBOW TROUT ACUTE LETHALITY TEST

**March 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-02-89 |
| Stock Acclimation Period (days): | 16 |
| Fish Lengths (mean±SD) (mm): | 39.0 ± 4.0; 39.1 ± 3.38 |
| Fish Weights (mean±SD) (g): | 0.54 ± 0.24; 0.49 ± 0.13 |
| Loading Rates (L/g/d): | 0.9; 1.02 |

**June 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-06-89; Rbt-07-89; Rbt-08-89 |
| Stock Acclimation Period (days): | 12; 9 |
| Fish Lengths (mean±SD) (mm): | 44.6 ± 4.9; 35.9 ± 5.5; 38.1 ± 4.9 |
| Fish Weights (mean±SD) (g): | 0.80 ± 0.33; 0.45 ± 0.12; 0.51 ± 0.12 |
| Loading Rates (L/g/d): | 0.67; 1.1; 0.98 |

**July 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-09-89; Rbt-10-89 |
| Stock Acclimation Period (days): | 12; 9; 11 |
| Fish Lengths (mean±SD) (mm): | 38.6 ± 3.47; 43.6 ± 3.6; 35.1 ± 2.6; 37.3 ± 45 |
| Fish Weights (mean±SD) (g): | 0.49±0.19; 0.74±0.25; 0.37±0.1; 0.48±0.17 |
| Loading Rates (L/g/d): | 1.03; 0.68; 1.35; 1.09 |

**August 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-12-89 |
| Stock Acclimation Period (days): | 11; 16; 14 |
| Fish Lengths (mean±SD) (mm): | 42.5 ± 4.1 |
| Fish Weights (mean±SD) (g): | 0.62 ± 0.19 |
| Loading Rates (L/g/d): | 0.81 |

**September 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-14-89 |
| Stock Acclimation Period (days): | 13; 14; 9 |
| Fish Lengths (mean±SD) (mm): | 46.8 ± 4.9 |
| Fish Weights (mean±SD) (g): | 1.05 ± 0.35; |
| Loading Rates (L/g/d): | 0.48 |

**December 1989**

| | |
|---|---|
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 10 L; 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-22/89; Rbt-23-89; Rbt-24-89 |
| Stock Acclimation Period (days): | 18; 6; 35 |
| Fish Lengths (mean±SD) (mm): | 34.3 ± 2.45; 34.4 ± 2.3; 43.3 ± 3.0 |
| Fish Weights (mean±SD) (g): | 0.35 ± 0.09; 0.36 ± 0.09; 0.72 ± 0.21 |
| Loading Rates (L/g/d): | 0.72; 0.69; 0.69 |

TABLE B.2: CONDITIONS OF RAINBOW TROUT ACUTE LETHALITY TEST

| | |
|---|---|
| **January 1990** | |
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L; 10 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-01-90; Rbt-02-90; Rbt-03-90 |
| Stock Acclimation Period (days): | 3; 12; 7 |
| Fish Lengths (mean±SD) (mm): | 36.7 ± 4.6; 31.2 ± 3.7; 38.9 ± 2.3 |
| Fish Weights (mean±SD) (g): | 0.40 ± 0.16; 0.3 ± 0.07; 0.45 ± 0.1 |
| Loading Rates (L/g/d): | 1.3; 0.8; 0.6 |
| **February 1990** | |
| Test Type: | Static |
| Test Temperature: | 15 ± 1°C |
| Test Volume: | 20 L |
| Photoperiod: | 12 hours light/12 hours dark |
| Stock Source: | Rainbow Springs Hatchery, Thamesford, Ontario |
| Stock Number: | Rbt-05-90 |
| Stock Acclimation Period (days): | 9; 19 |
| Fish Lengths (mean±SD) (mm): | 41.3 ± 4.57; 39.4 ± 3.2 |
| Fish Weights (mean±SD) (g): | 0.50 ± 0.16; 0.76 ± 0.13 |
| Loading Rates (L/g/d): | 1.0; 1.1 |

0% and 100% mortality, plus a minimum of two concentrations resulting in partial mortality (Bennett, 1952). The binomial method was used when only 0% and 100% responses were observed (Stephan, 1977). The trimmed Spearman-Karber method, which is not subject to some of the deficiencies of probit and logit models (Hamilton, 1977), was used for some data sets, particularly those with only one partial kill and/or those with slightly anomalous (although valid) dose-response relationships.

## B.2 Daphnia Toxicity

Forty-eight hour Daphnia magna acute tests were performed according to the OMOE protocol (1988a).

### Culture Conditions

Daphnia magna were obtained five years ago from monoculture stocks at the Canadian Centre for Inland Waters, Great Lakes Biolimnology Laboratory in Burlington, Ontario. Taxonomic verification was completed using an invertebrate key (Pennak, 1953), by BEAK taxonomic specialists.

Daphnia stocks were fed a mixed solution of Selenastrum and Chlorella algae every 48 hours in glass culture aquaria containing laboratory dilution water held at 20±1°C. The photoperiod was maintained at 16-hours light, 8-hours dark. Culture and dilution water was dechlorinated Brampton tap water.

### Test Conditions

The tests were conducted according to the procedure outline in the OMOE protocol (1988a). Gravid adults selected from the stock culture were isolated in 1-L vessels containing laboratory dilution water and first instar daphnids were collected and isolated in a new 400 mL vessel. First instar daphnids (less than 24 hours in age) were then collected from the third or subsequent broods to be used in the toxicity tests. The young from different adults were combined before distribution to the various test vessels.

The bioassays were conducted in 200 mL glass containers. The exposure concentration series were based on a series of dilution factors, e.g., 100, 70, 50, 30, 20 and

10% vol/vol. Additional lower concentrations were prepared after 24 hours if the results indicated that the samples were toxic in the lowest effluent dilution. Each test was accompanied by a control concentration which contained organisms in dilution water only, and was subjected to the same test conditions as the test solutions.

All tests were conducted at a temperature of 20±2°C under a controlled light regime (16-hours light/8-hours darkness).

Dissolved oxygen, pH, temperature and conductivity of test solutions were recorded prior to and after effluent exposure. Hardness was measured in lowest and highest test concentrations and control. Daphnia mortality was recorded at 24 hours and 48 hours. The 48-hour median lethal concentration (LC50) and 95% confidence limits were determined as described in Section B.1. The specific details of the bioassays conducted are presented in Table B.3.

## B.3 Fathead Minnow Larval Survival and Growth

The tests were completed in three replicates according to the U.S. EPA protocol (1989).

### Culture Conditions

Sexually mature fathead minnow (Pimephales promelas) females (6) and males (2) were placed in each breeding tank containing Brampton tap water at 25±1°C two weeks prior to testing. The photoperiod for the spawning tanks was maintained at 16 hours light and 8 hours dark at a illumination level of 100 ft. c. The breeding fish were fed frozen brine shrimp (Artemia salina) and tropical fish food flakes twice daily. Spawning females produced spawns of 100 to 400 eggs each. Once a day, the spawning substrates were inspected and were placed in separate incubation tanks. During the incubation period, the spawning substrates were vigorously aerated and the eggs were examined daily for fungal growth and viability. Newly hatched larvae were transferred daily from egg incubation tanks to the rearing tanks with a large bore pipette. The rearing tanks were held at the water temperature at 25±1°C under 16 hours light/8 hours dark photoperiod and 100 ft. c. light intensity.

Newly hatched fathead minnow larvae were fed freshly-hatched brine shrimp three times daily.

## TABLE B.3: CONDITIONS OF ACUTE LETHALITY TEST WITH *DAPHNIA MAGNA*

| | |
|---|---|
| Temperature: | 20±2°C |
| Light Quality: | Ambient laboratory illumination |
| Light Intensity: | 50-100 footcandles (ft c) |
| Photoperiod: | 16 hours light/8 hours dark |
| Size of Test Solution: | 250 mL glass vessel |
| Volume of Test Solution: | 200 mL |
| Age of Test Animals: | 1-24 hours (neonates) |
| No. Animals per Test Vessel: | 10 |
| No. of Replicate Test Vessels per Concentration: | 1 |
| Total No. Organisms per Concentration: | 10 |
| Feeding Regime: | Not required |
| Aeration: | None |
| Dilution Water: | Brampton dechlorinated tap water |
| Test Duration: | 48 h (static tests) |
| Effect Measured: | Mortality - no movement of body or appendages on gentle prodding (LC50) |
| Stock Source: | CCIW, Burlington, Ontario |

## Test Conditions

Six or more exposure concentrations were selected for testing based on preliminary test results with Daphnia magna and rainbow trout. The tests were performed according to the U.S. EPA protocol (1989). The concentration series was replicated in triplicate. The tests were initiated by placing ten, newly hatched fathead minnow larvae into each test vessel. All test containers were held at 25±1°C temperature under ambient laboratory light with a photoperiod of 16 hours light and 8 hours darkness. The fish in each test chamber were fed 0.2 mL of a concentrated suspension of newly hatched brine shrimp three times daily. The test solutions were renewed daily with freshly prepared concentrations. The larval survival and physical/chemical parameters such as dissolved oxygen, temperature, conductivity, hardness and alkalinity were monitored daily. After seven days of exposure, the tests were terminated, the larvae from each test chamber were sacrificed, rinsed in distilled water, placed on an aluminum dish, and dried at 105°C temperature in a Fisher Isotemp oven for 24 hours. The dried dishes were cooled in a dessicator, before measuring the composited fish weights. The specific details of the bioassays performed are shown in Table B.4.

Survival data were used to statistically estimate a chronic LC50 using techniques described in Section B.1. Adult survival was also evaluated by hypothesis testing, according to the EPA protocol, using an electronic statistical package (Toxstat, Version 2.0, University of Wyoming). First, the Shapiro-Wilks Test was used to identify whether the data were normally distributed, then Bartlett's Test was used to assess homogeneity of variance. If the data passed both tests, an ANOVA was performed, followed by Dunnett's test (Dunnett, 1955) to identify treatments (concentrations) which were statistically different from the control (95% confidence). If the data failed either (or both) the Shapiro-Wilks or Bartlett's test, Steel's Many One Rank Test (Steel, 1959) was used following ANOVA. In either case, the NOEC and LOEC for fish survival were identified.

Fish growth was then evaluated by comparing the mean weight of organisms exposed to each concentration in which fish survival was not significantly affected, to that of control organisnms. The NOEC and LOEC for fish growth were identified as described above.

## TABLE B.4: SUMMARY OF TEST CONDITIONS FOR FATHEAD MINNOW (*PIMEPHALES PROMELAS*) LARVAL SURVIVAL AND GROWTH TEST

| | |
|---|---|
| Test Type: | Static renewal |
| Temperature (°C): | 25 ± 1°C |
| Light Quality: | Ambient laboratory illumination |
| Light Intensity: | 50-100 ft-C |
| Photoperiod: | 16 hours light/8 hours dark |
| Test Chamber Size: | 1-L containers |
| Test Solution Volume: | 500 mL/replicate |
| Renewal of Test Concentrations: | Daily |
| Age of Test Organisms: | Newly hatched larvae |
| Larvae/Test Vessel: | 10 larvae/vessel |
| Replicate Chambers/Concentration: | 3 |
| Feeding Regime: | Feed 0.2 mL newly hatched brine shrimp nauplii three times daily, 4 hours between feedings (at the beginning, midway and the end of the work day) |
| Aeration: | None |
| Dilution Water: | Dechlorinated Brampton tap water |
| Effluent Concentrations: | At least 6 and a control |
| Test Duration: | 7 days |
| Effects Measured: | Survival and growth (increase in weight) |

If the LOEC for fish growth occurred at a lower concentration than did the LOEC for survival, then the LOEC and NOEC for growth were used to estimate the Chronic Value (Ch.V.) of the sample (geometric mean of NOEC and LOEC). Otherwise, the NOEC and LOEC for survival were used to estimate the Ch.V. of the sample.

## B.4 *Ceriodaphnia dubia* Survival and Growth

### Culture Conditions

*Ceriodaphnia dubia* stocks were fed daily a suspension of combined solution of algae, fermentated trout chow, Fleischman's yeast and Cerophyl$^{R}$ (powdered, dried cereal leaves). The feeding rate was 5 mL/L of culture medium. The culture stocks were maintained in a 50-L glass aquarium, containing laboratory dilution water at 25±1°C. The photoperiod was 16 hours light, 8 hours dark at the 100 ft-C light intensity. The culture populations were maintained at a loading rate of less than 1,000 animals/L of medium to minimize crowding and gametogenesis.

Primary brood animals containing eggs were selected from the stock culture and were isolated in 50 mL beakers containing 15 mL of dilution water and 0.2 mL of food suspension for 24 hours. Initially, the young produced and media were discarded each day, and brood females were transferred to fresh solution. The young produced in the fourth and subsequent broods were used as the secondary parental stock. Neonates produced in the fifth and subsequent broods of secondary parental stock were used in tests. All neonates were less than 24 hours old when exposure began.

### Test Conditions

The tests were completed according to the protocol developed by the U.S. EPA (1989). The tests commenced within 48 hours of sample collection using less than 24-hour-old *C. dubia* instars generated as described above. The exposure concentration series were as follows: 5, 10, 20, 30, 50, 70 and 100%. Ten animals were exposed to each effluent concentration, and only one animal was placed in each exposure vessel. The bioassays were conducted in 25 mL polyethylene vessels with 15 mL of test solution. Each bioassay was accompanied by a control containing dilution water only, but subjected to the same test conditions as the effluent concentrations.

All tests were conducted at 25±1°C under the same photoperiod as the stock culture. Each surviving test organism was transferred daily into a new test vessel containing 15 mL of freshly prepared test solution and 0.2 mL food suspension/15 mL of test solution. Once the individual C. dubia had matured and produced young (on about the third day), only the adult was transferred to fresh effluent solution and remaining young were sacrificed and counted. Dissolved oxygen, pH, temperature and conductivity were recorded at the beginning and end of each 24-hour exposure period in the high, medium and low test concentration and control. Alkalinity and hardness were measured at the beginning of each 24-hour exposure time in the highest test concentration and control. The specific details of the bioassays performed are presented in Table B.5.

Adult survival data were used to statistically estimate a chronic LC50 using techniques described in Section B.1. Adult survival was also evaluated according to the EPA protocol using Fisher's Exact Test (available as an electronic statistical package: (Toxstat, Version 2.0, University of Wyoming). The highest concentration which resulted in no significant reduction in survival (NOEC) compared to controls and the lowest concentration which resulted in a significant reduction in survival (LOEC) were identified.

Reproduction data were then analyzed. First, the Shapiro-Wilks Test was used to identify whether the data were normally distributed, then Bartlett's Test was used to assess homogeneity of variance. If the data passed both tests, an ANOVA was performed, followed by Dunnett's test (Dunnett, 1955) to identify treatments (concentrations) in which the number of neonates produced were statistically different from the control (95% confidence). If the data failed either (or both) the Shapiro-Wilks or Bartlett's test, Steel's Many One Rank Test (Steel, 1959) was used following ANOVA. In either case, the NOEC and LOEC for daphnid reproductions were identified.

If the LOEC for reproduction occurred at a lower concentration than did the LOEC for survival, then the LOEC and NOEC for reproduction were used to estimate the Chronic Value (Ch.V.) of the sample (geometric mean of NOEC and LOEC). Otherwise, the NOEC and LOEC for survival were used to estimate the Ch.V. of the sample.

## TABLE B.5: SUMMARY OF TEST CONDITIONS FOR *CERIODAPHNIA* SURVIVAL AND REPRODUCTION BIOASSAY

| | |
|---|---|
| Test Type: | Static renewal |
| Test Temperature: | 25 ± 1°C |
| Light Quality: | Ambient laboratory light |
| Light Intensity: | 100 ft-C |
| Photoperiod: | 16 hours light/8 hours dark |
| Feeding Regime: | 0.2 mL/15 mL, daily |
| Age of Test Organisms: | Less than 24 hours old |
| Stock Source: | U.S. EPA, Duluth Laboratory |
| Number of Organisms per Vessel: | 1 |
| Number of Replicates per Concentration: | 10 |
| Test Vessel Size: | 25 mL |
| Test Volume: | 15 mL |
| Removal of Test Concentrations: | Daily |
| Aeration: | None |
| Dilution Water: | Dechlorinated Brampton tap water |
| Test Duration: | 7 days |

# APPENDIX C:

## Quality Assurance/Quality Control

## APPENDIX C: QUALITY ASSURANCE/QUALITY CONTROL

### C.1 Toxicity Tests

**Standard Operating Procedures**

BEAK's Toxicity Laboratory Quality Assurance/Quality Control (QA/QC) program was based on U.S. EPA Standards of "Good Laboratory Practise" (U.S. EPA, 1987). BEAK has also incorporated, where appropriate, elements of the OECD (1980) GLP program developed for chemical analytical laboratories. These practices included such elements as the following:

- test protocols were stored in a central location at the laboratory for easy access by all staff;
- responsibilities for all laboratory tasks (e.g., QA/QC activities, maintenance of cultures, toxicity testing, etc.) were clearly defined and documented;
- samples were logged in on receipt and given an individual sample and test number to which was referred in subsequent documentation (e.g., on bench sheets);
- bench sheets were stored until test completion at designated locations in each testing area of the laboratory; and
- records were maintained on the history of the test animals (e.g., acclimation period, culture age, mean weights, etc.).

Other details of BEAK's QA/QC practises are outlined in Hart (1990) and Environment Canada (1990).

**Control Responses in Tests**

The MOE protocols for rainbow trout toxicity testing (MOE, 1983b) and Daphnia magna toxicity testing (MOE, 1983a) require less than 10% mortality among control organisms for a test to be valid. Any tests that did not meet this specification would immediately be terminated and re-set. This only occurred in one *Daphnia magna* test and in no rainbow trout tests.

The EPA protocols for fathead minnow survival and growth and *Ceriodaphnia dubia* survival and reproduction tests allow a maximum of 20% control mortality. Although they are not specifically discussed in the protocols, unusual patterns of mortality in test concentrations (e.g., if no dose-response relationship was evident) were also determined to be invalid responses. As with the acute tests, violations of the above standards resulted in immediate test termination and a new test was begun.

**Reference Toxicant Testing**

Reference toxicant tests were conducted on a regular basis using sodium pentachlorophenate (NaPCP) as the toxicant. The tests provided a baseline against which any major changes in the test systems could be detected. Data corresponding to the duration of the STP survey (1989-1990) are presented in Figures C.1 to C.3. Control limits of mean ± 2 standard deviations were used to judge routine performance (as outlined in Environment Canada (1990) and MOE (1990)). The mean and control limits for rainbow trout and *Daphnia magna* were calculated from historical data and are stable over time. The mean and control limits for fathead minnows and *Ceriodaphnia dubia* are based on data presented in figures. The results generated for all test organisms fell within the normal range of test variability.

## C.2 Chemical Analyses

### C.2.1 OMOE Laboratory

The Ontario Ministry of the Environment laboratories routinely monitor analytical performance in order to ensure immediate detection and correction of analytical performance. In addition to QC data for specific analytical methods, a discussion of general QA/QC practises is presented in annual reports. The most recent report available at the time of preparation of this study was OMOE (1988c).

Figure C.1 Control Chart for Rainbow Trout Acute Lethality Test Using Sodium Pentachlorophenate

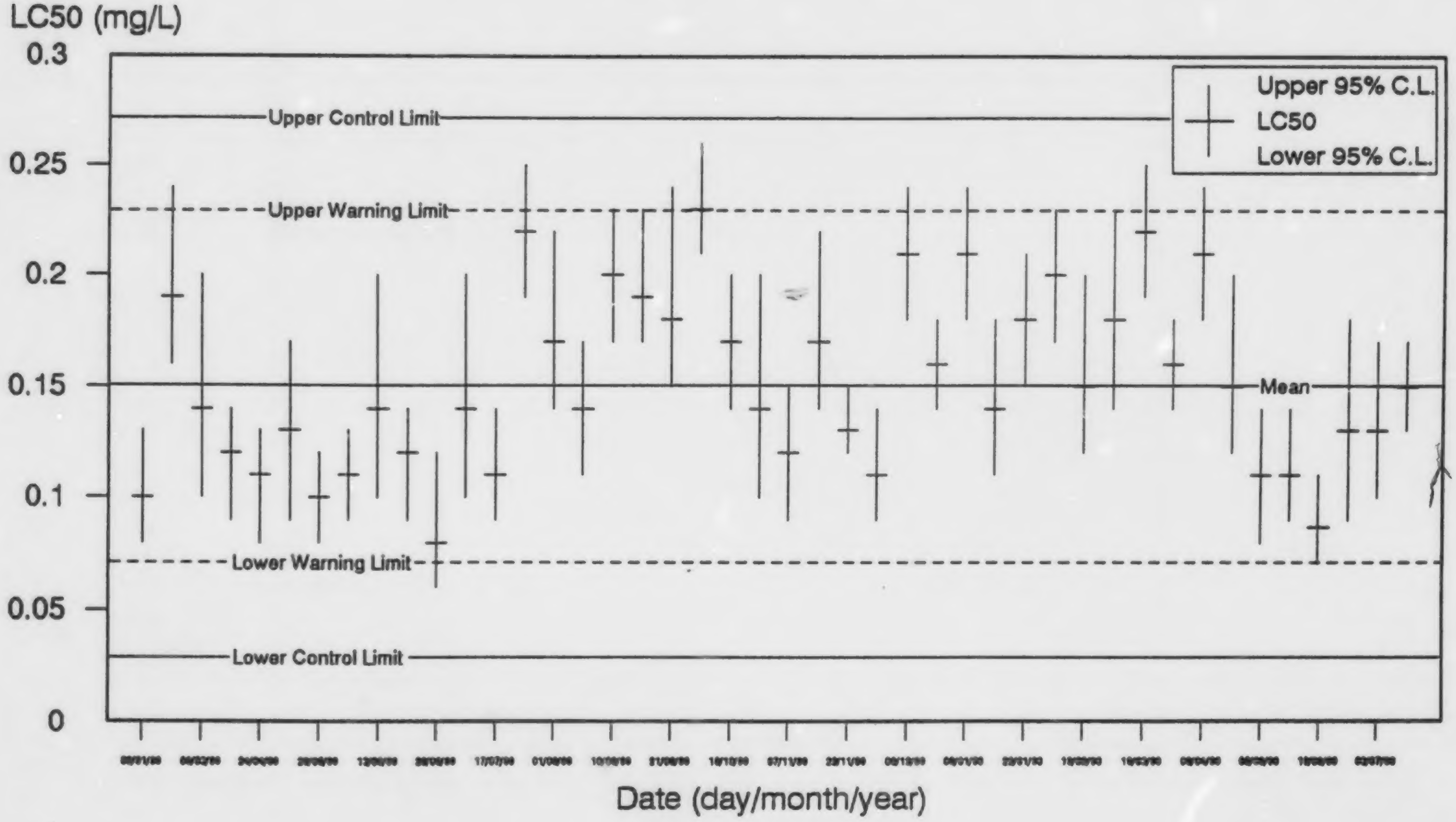


Figure C.2 Control Chart for Daphnia magna Acute Lethality Test Using Sodium Pentachlorophenate

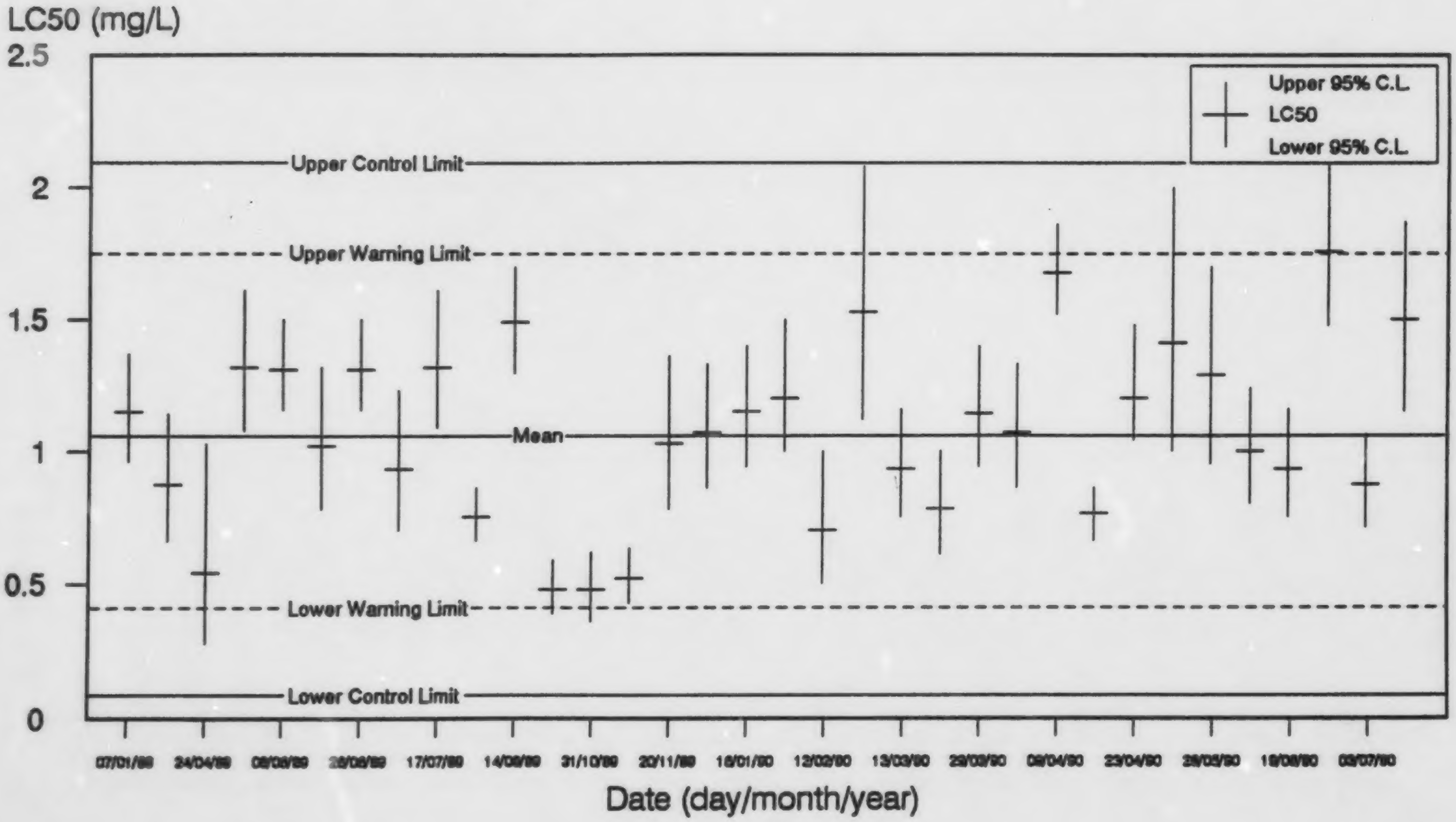


**Figure C.3a** **Control Chart for 7-Day Fathead Minnow Test Using Sodium Pentachlorophenate**

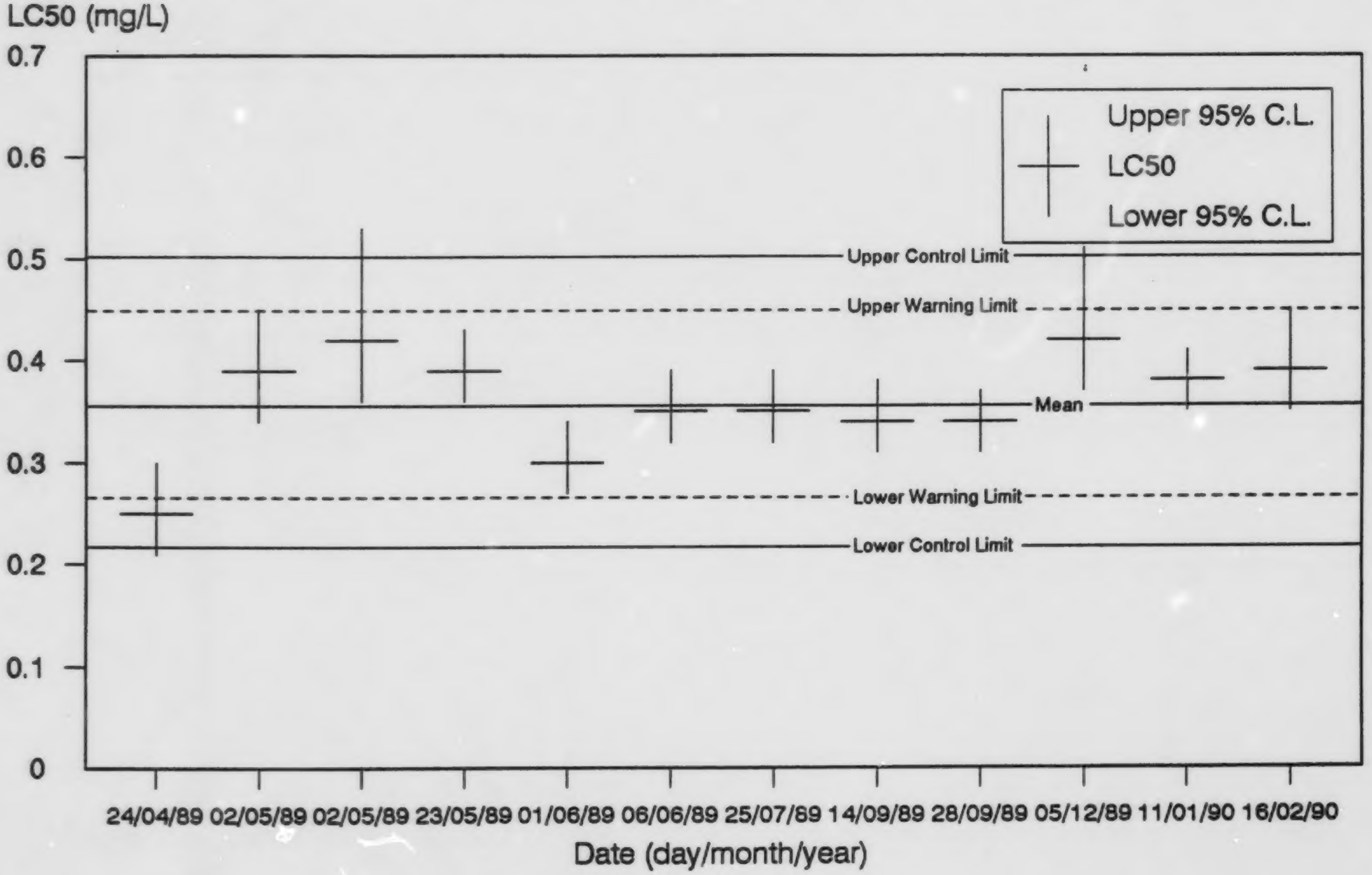


Figure C.3b Control Chart for 7-Day Fathead Minnow Test Using Sodium Pentachlorophenate

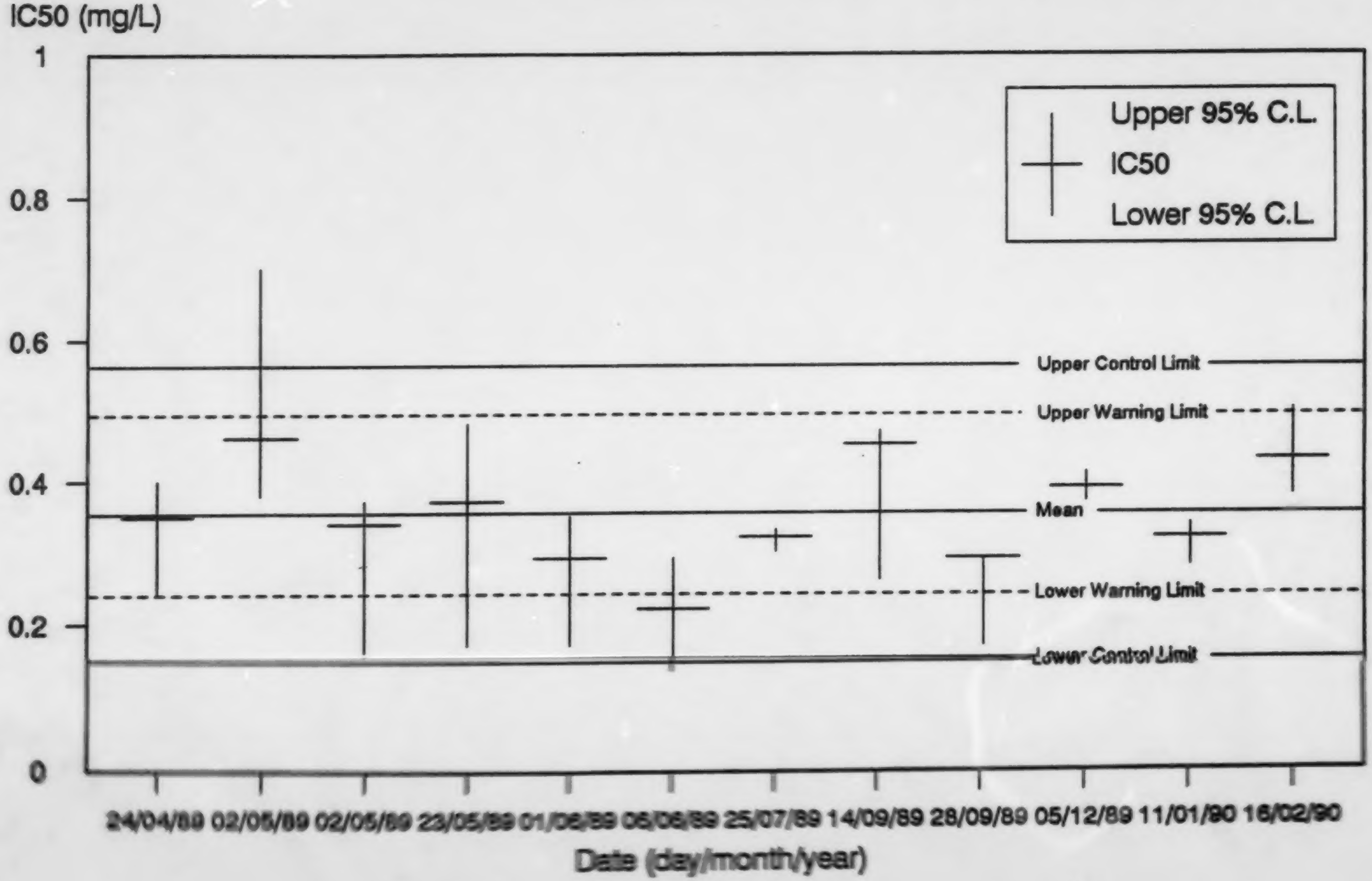


Figure C.4a Control Chart for 3-Brood *C. dubia* Test Using Sodium Pentachlorophenate

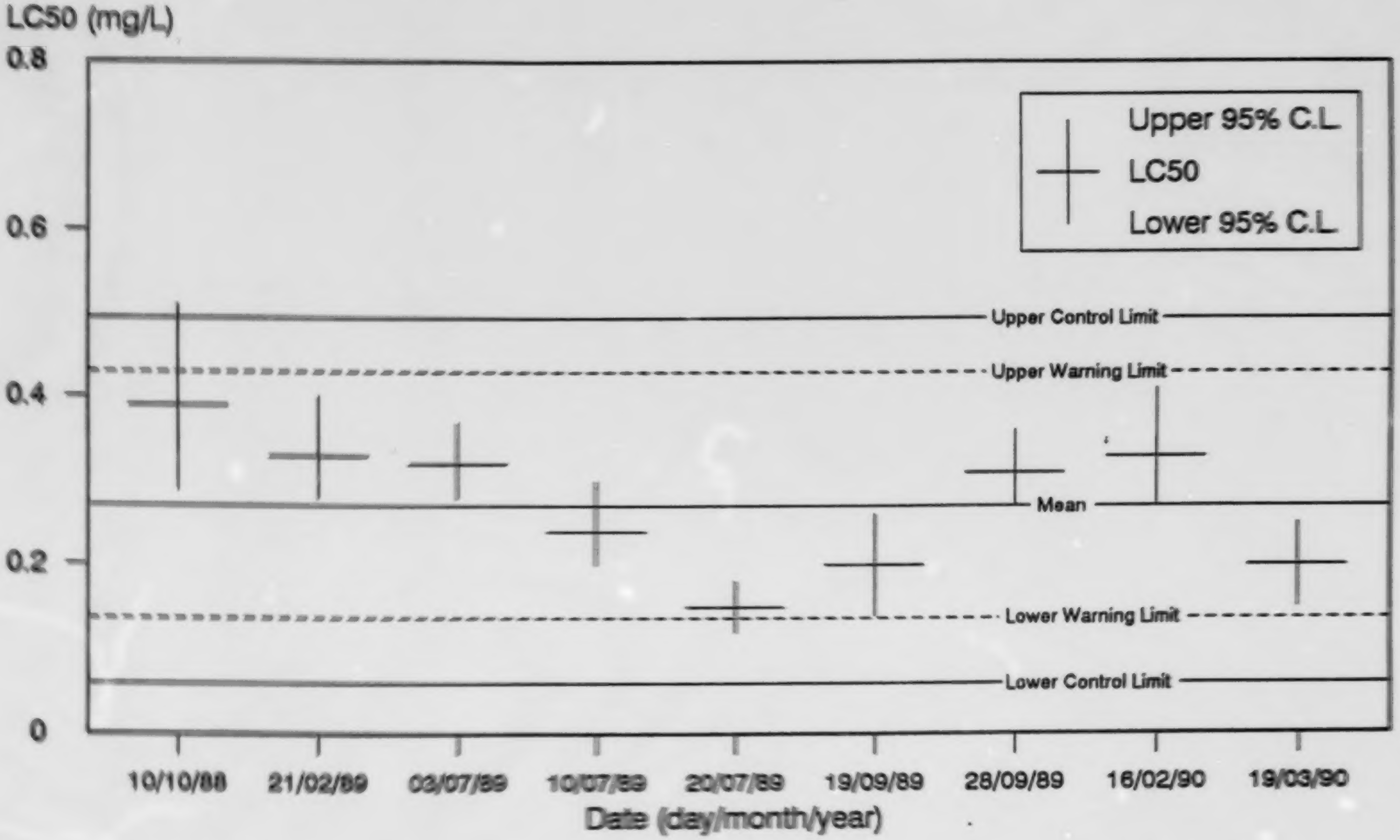
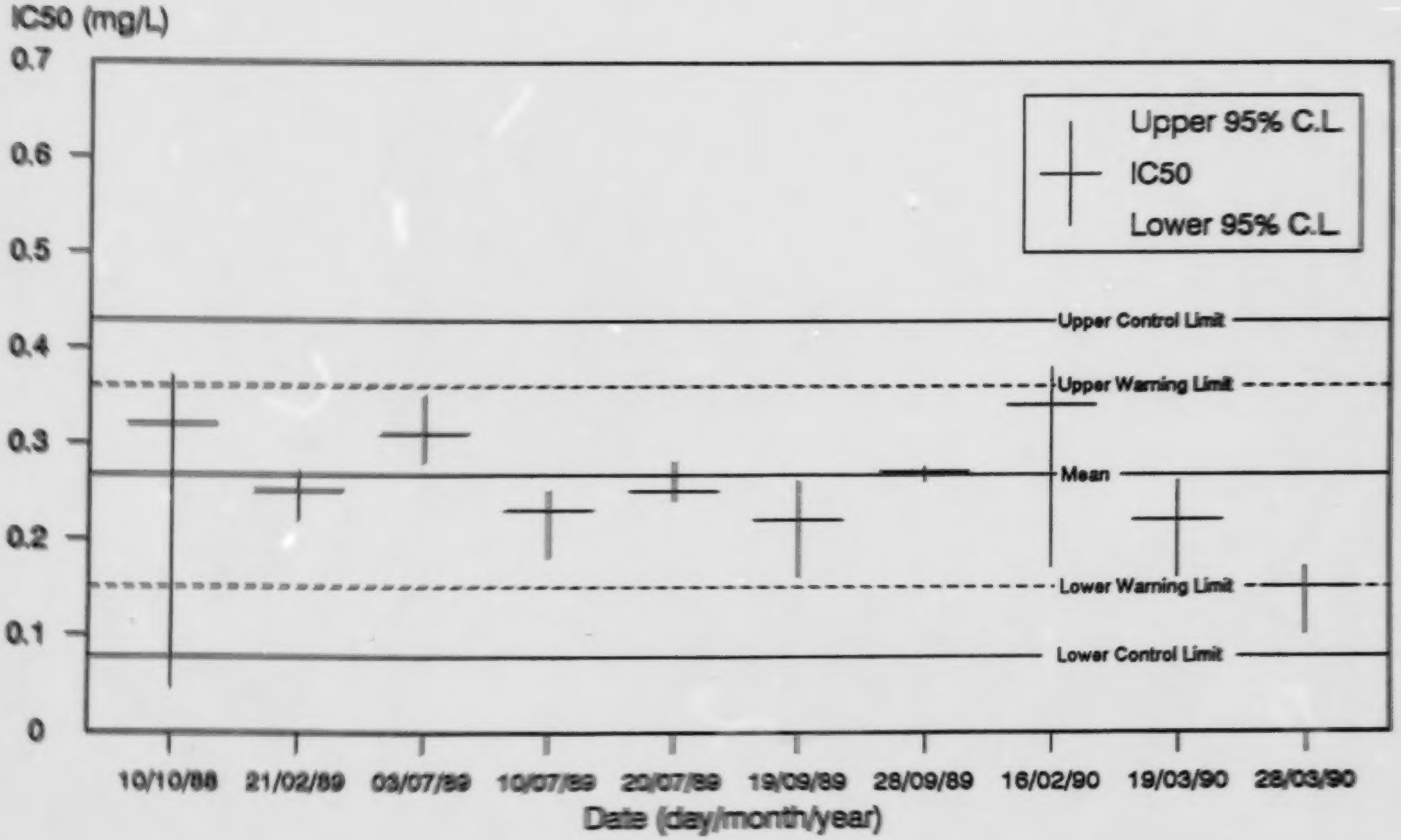


Figure C.4b Control Chart for 3-Brood _C._ _dubia_ Test Using Sodium Pentachlorophenate



Performance of the OMOE laboratory was further evaluated by submission of QC check samples without the knowledge of OMOE staff. Once during each sampling period at each STP, a set of chemical samples was split into duplicates and submitted for analysis of conventional parameters and metals.

Duplicate performance on conventional parameters was usually good (Table C.1). The difference between duplicate concentration values expressed as a percent of the mean value ranged from 0 to 166%, but was less than 22% on average. The greatest range between duplicate values was often associated with concentrations approaching the method detection limit (MDL), where analytical precision is typically poorer.

Four of the duplicate samples were spiked with a known quantity of ammonia (11.3 mg/L ammonia-nitrogen). Analytical accuracy was good (Table C.2), with estimates of spike quantity ranging from 86 to 108% of actual quality.

The differences between duplicate metal concentrations tended to be greater than observed for conventional parameters. Expressed as a percentage of the mean value for each pair of observations, the difference between duplicates averaged between 0 and 38% for all parameters, but ranged as high as 199%. As observed with conventional parameters, extreme differences were frequently associated with concentrations near the MDL.

### C.2.2 Field versus Toxicity Laboratory Analyses

As discussed in Section 2.3, total ammonia and residual chlorine analyses were performed in the field (CH2M Hill) and at the toxicity laboratory (BEAK) on separate instruments by separate analysts. In order to determine comparability between data generated in the field and at the laboratory, simultaneous analyses were periodically performed by both analysts. The most extensive of these QC checks were conducted prior to the summer sampling season and prior to the second set of winter samples. The following sections include the combined data from those sessions.

#### Total Ammonia

Total ammonia levels measured in the field and laboratory were used for two purposes: to demonstrate any major changes in ammonia levels during sample transport, and in

## TABLE C.1: ANALYTICAL PERFORMANCE ON BLIND DUPLICATE SAMPLES

| | Difference Between Duplicates as Percent of Mean Concentration | | |
|---|---|---|---|
| Parameter | Mean of All Occurrences | Range | Range of Concentrations Measured |
| **Conventionals (mg/L)** | | | |
| BOD | 18 | 0-114 | 2.0-53.7 |
| Dissolved Organic Carbon | 3.9 | 0-13 | 4.0-18.4 |
| Nitrate-Nitrogen | 7.5 | 0-55 | LT 0.05-20.90 |
| Nitrite-Nitrogen | 22 | 0-166 | LT 0.005-4.200 |
| Total Ammonia-Nitrogen | 4.4 | 0-25 | 0.10-16.2 |
| Total Suspended Solids | 21 | 0-55 | LT 2.5-33.0 |
| Volatile Suspended Solids | 17 | 0-50 | LT 2.5-26.0 |
| **Metals (mg/L)** | | | |
| Aluminum | 38 | 0-164 | LT 0.02-1.10 |
| Arsenic | 20 | 0-156 | LT 0.01-0.08 |
| Beryllium | 0 | | LT 0.01 |
| Cadmium | 0 | | LT 0.01 |
| Calcium | 20 | 0-195 | 0.08-205.1 |
| Chromium | 17 | 0-172 | LT 0.005-0.066 |
| Cobalt | 13 | 0-190 | LT 0.005-0.190 |
| Copper | 25 | 0-167 | LT 0.005-0.087 |
| Iron | 38 | 0-187 | LT 0.02-5.30 |
| Lead | 15 | 0-181 | LT 0.01-0.40 |
| Magnesium | 14 | 0-200 | LT 0.01-27 |
| Manganese | 11 | 0-133 | LT 0.01-0.93 |
| Mercury | 38 | 0-179 | LT 0.00002-0.00071 |
| Molybdenum | 13 | 0-162 | LT 0.005-0.048 |
| Nickel | 25 | 0-199 | LT 0.01-4.40 |
| Selenium | 13 | 0-100 | LT 0.01-0.03 |
| Silver | 0 | | LT 0.10 |
| Strontium | 14 | 0-180 | LT 0.01-8.1 |
| Vanadium | 0 | | LT 0.02 |
| Zinc | 21 | 0-120 | LT 0.01-0.13 |

LT = Less than.

TABLE C.2: ANALYSIS OF SAMPLES SPIKED WITH AMMONIA

| Sample I.D. | Ammonia Concentration (mg/L) | | | |
|---|---|---|---|---|
| | Untreated Sample | Spiked Sample | Difference | Spike Amount |
| Stratford, Comp. 2 | 14.70 | 26.50 | 11.80 | 11.3 |
| | 0.10 | 9.85 | 9.75 | 11.3 |
| | 3.65 | 15.80 | 12.15 | 11.3 |
| | 11.60 | 23.20 | 11.60 | 11.3 |

order to estimate un-ionized ammonia levels which were used in the decision-making process for toxicity test initiation. It was recognized that analysis of ammonia using the Hach kits would likely be associated with greater variability and inaccuracy than OMOE results. For statistical evaluation of the relationship between sample toxicity and ammonia levels, only the OMOE analytical laboratory results were used.

With this in mind, it was judged that effluent sample ammonia concentrations measured by BEAK and CH2M Hill showed reasonable agreement (Table C.3). Analysis of standard samples also indicated a reasonable degree of accuracy (Table C.4).

### Residual Chlorine

Free residual chlorine was not detected in any samples by the time they arrived at the toxicity laboratory; therefore, no comparison of FRC results between analysts was completed. Total residual chlorine levels measured in effluent samples showed good agreement (Table C.5). Comparison to analytical standards was also excellent (Table C.6).

## TABLE C.3: COMPARISON OF TOTAL AMMONIA CONCENTRATIONS (mg/L) MEASURED BY BEAK AND CH2M HILL IN SIMULTANEOUS ANALYSIS OF EFFLUENT SAMPLES

| BEAK | CH2M Hill | Mean | Difference As % of Mean |
|---|---|---|---|
| 16.0 | 13.2 | 14.6 | 19 |
| 16.0 | 13.2 | 14.6 | 19 |
| 16.8 | 13.2 | 15.0 | 24 |
| 20.4 | 14.8 | 17.6 | 32 |
| 19.2 | 14.0 | 16.6 | 31 |
| 18.0 | 12.4 | 15.2 | 37 |
| 19.2 | 12.0 | 15.6 | 46 |
| 17.2 | 10.4 | 13.8 | 49 |
| 6.8 | 4.0 | 5.4 | 52 |
| 4.4 | 3.8 | 2.5 | 41 |

## TABLE C.4: ANALYSIS OF TOTAL AMMONIA STANDARDS BY BEAK AND CH2M HILL

| Standard Concentration | BEAK | CH2M Hill |
|---|---|---|
| 0.20 mg/L | 0.26 | 0.20 |
| | | 0.19 |
| | | 0.22 |
| 0.25 mg/L | 0.35 | 0.25 |
| | 0.34 | 0.24 |
| | 0.35 | 0.24 |
| 0.40 mg/L | 0.39 | 0.38 |
| | | 0.39 |
| | | 0.42 |
| 0.50 mg/L | 0.62 | 0.44 |
| | 0.61 | 0.43 |
| | 0.61 | 0.45 |
| 0.60 mg/L | 0.55 | 0.55 |
| | | 0.55 |
| | | 0.61 |
| 1.00 mg/L | | 0.94 |
| | | 0.95 |
| | | 0.92 |
| 1.25 mg/L | 1.18 | 1.00 |
| | 1.19 | 0.98 |
| | 1.17 | 0.98 |

## TABLE C.5: COMPARISON OF TRC (mg/L) MEASURED BY BEAK AND CH2M HILL IN SIMULTANEOUS ANALYSIS OF EFFLUENT SAMPLES

| BEAK | CH2M Hill | Mean | Difference As % of Mean |
|---|---|---|---|
| LT 0.02 | LT 0.02 | LT 0.02 | - |
| 0.02 | LT 0.02 | LT 0.02 | - |
| LT 0.02 | LT 0.02 | LT 0.02 | - |
| 0.085 | 0.080 | 0.083 | 6.1 |
| LT 0.02 | LT 0.02 | LT 0.02 | - |
| 0.340 | 0.340 | 0.340 | 0.0 |
| 0.370 | 0.285 | 0.085 | 26 |
| 0.250 | 0.270 | 0.260 | 7.7 |

LT = Less than.

TABLE C.6: ANALYSIS OF TOTAL RESIDUAL CHLORINE STANDARDS BY BEAK AND CH2M HILL

| Standard (mg/L) | CH2M Hill | BEAK |
|---|---|---|
| 0.2 | 0.230 | 0.160 |
| | 0.227 | 0.200 |
| 0.4 | 0.420 | 0.480 |
| | 0.420 | 0.400 |
| | 0.405 | 0.440 |
| 0.6 | 0.550 | 0.580 |
| | 0.554 | 0.550 |
| | 0.555 | 0.540 |
| | 0.557 | 0.550 |
| 1.0 | 0.910 | 1.055 |
| | 0.950 | 0.940 |

# APPENDIX D

## Toxicity of Effluent Parameters to Test Organisms

## TABLE D.1: TOXICITY OF EFFLUENT PARAMETERS TO RAINBOW TROUT AS REPORTED IN THE LITERATURE

| Chemical/ Element | Approximate Value | End-Point [a] | Comment | Reference |
|---|---|---|---|---|
| Ag (mg/L) | 0.010 | $LC_{50}$ | Species mean acute value | MOE, 1987 |
| Al (mg/L) | 5.0 | Approx. $LC_{50}$ | Basic pH | Craig et al., 1985 |
| As (mg/L) | 13 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1980a |
| Be (mg/L) | 3.0 | $LC_{50}$ | Other fish species | MOE, 1987 |
| Cd (mg/L) | 0.0036 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1984a |
| Co (mg/L) | 0.48 | 28-day $LC_{50}$ | | MOE, 1987 |
| Cr (mg/L) | 69 | $LC_{50}$ | Species mean acute value (hexavalent) | U.S. EPA, 1984b |
| Cu (mg/L) | 0.11 | $LC_{50}$ | Equation [c] | U.S. EPA, 1980c |
| Fe (mg/L) | 1.0 | $LC_{100}$ | At hatch | MOE, 1987 |
| Hg (ug/L) | 270 | $LC_{50}$ | Species mean acute value (divalent) | MOE, 1987 |
| Mn (mg/L) | 2.9 | $LC_{50}$ | 28-day test/embryo larvae | MOE, 1987 |
| Mo (mg/L) | 0.76 | 28-day $LC_{50}$ | Embryo/larvae | MOE, 1987 |
| $NH_3$ (mg/L) [b] | 0.45 | $LC_{50}$ | | U.S. EPA, 1985a |
| Ni (mg/L) | 32 | $LC_{50}$ | Hardness = 240 mg/L | Environment Canada, 1979 |
| $NO_3$ (mg/L) | 6,000 | $LC_{50}$ | | CCREM, 1987 |
| $NO_2$ (mg/L) | 0.30 | Approx. $LC_{50}$ | | CCREM, 1987 |
| Pb (mg/L) | 18 | $LC_{50}$ | Fathead minnow | MOE, 1987 |
| Se (mg/L) | 9 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1980f |

## TABLE D.1: TOXICITY OF EFFLUENT PARAMETERS TO RAINBOW TROUT AS REPORTED IN THE LITERATURE (Cont'd)

| Chemical/ Element | Approximate Value | End-Point [a] | Comment | Reference |
|---|---|---|---|---|
| Sr (mg/L) | 0.23 | 28-day $LC_{50}$ | Embryo/larvae | MOE, 1987 |
| Sulphide (mg/L) | 0.013 | LC50 | | Smith et al., 1976 |
| TRC (mg/L) | 0.062 | LC50 | Species mean acute value | U.S. EPA, 1985b |
| V (mg/L) | 3.6 | 7-day $LC_{50}$ | | MOE, 1987 |
| Zn (mg/L) | 1.7 | $LC_{50}$ | Equation [c] | U.S. EPA, 1987 |

[a] Acute unless otherwise indicated.

[b] Un-ionized.

[c] Based on BEAK laboratory dilution water hardness of 150 mg/L.

## TABLE D.2: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO *DAPHNIA MAGNA* AS REPORTED IN THE LITERATURE

| Chemical/ Element | Approximate Value | End-Point [a] | Comment | Reference |
|---|---|---|---|---|
| Ag (mg/L) | 0.0017 | $LC_{50}$ | Species mean acute value (hardness = 40) | MOE, 1987 |
| Al (mg/L) | 3.3 | $LC_{50}$ | Species mean acute value | Craig *et al.*, 1985 |
| As (mg/L) | 5.3 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1980a |
| Be (mg/L) | 7.9 | $LC_{50}$ | Hardness = 180 | MOE, 1987 |
| Cd (mg/L) | 0.012 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1984a |
| Co (mg/L) | 0.010 | 16% Reproductive Impairment | 3-week exposure | MOE, 1987 |
| Cr (mg/L) | 0.023 | $LC_{50}$ | Species mean acute value (hexavalent) | U.S. EPA, 1984a |
| Cu (mg/L) | 0.060 | $LC_{50}$ | Equation [c] | U.S. EPA, 1980c |
| Fe (mg/L) | 5.9 | $LC_{50}$ | Three-week exposure[e] | MOE, 1987 |
| Hg (ug/L) | 5 | $LC_{50}$ | Species mean acute value (divalent) | U.S. EPA, 1980d |
| Mn (mg/L) | No data | | | |
| Mo (mg/L) | No data | | | |
| $NH_3$ (mg/L) | 1.6 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1983a |
| Ni (mg/L) | 3.3 | $LC_{50}$ | Equation [c] | U.S. EPA, 1980e |
| $NO_3$ (mg/L) | No data | | | |
| $NO_2$ (mg/L) | No data | | | |
| Pb (mg/L) | 0.45 | $LC_{50}$ | Species mean acute value | CCREM, 1987 |

TABLE D.2: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO *DAPHNIA MAGNA* AS REPORTED IN THE LITERATURE (Cont'd)

| Chemical/ Element | Approximate Value | End-Point [a] | Comment | Reference |
|---|---|---|---|---|
| Se (mg/L) | 0.71 | $LC_{50}$ | Species mean acute value | U.S. EPA, 1980i |
| Sr (mg/L) | 42 | 16% Reproductive Impairment | 3 week exposure | MOE, 1987 |
| Sulphide (mg/L) | No data | | | |
| TRC (mg/L) | 0.028 | LC50 | Species mean acute value | U.S. EPA, 1985b |
| V (mg/L) | No data | | | |
| Zn (mg/L) | 0.54 | $LC_{50}$ | Equation [c] | |

[a] Acute unless otherwise indicated.

[b] Un-ionized.

[c] Based on BEAK laboratory dilution water hardness of 150 mg/L.

## TABLE D.3: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO FATHEAD MINNOWS AS REPORTED IN THE LITERATURE

| Chemical/ Element | Approximate Value | End-Point | Comment | Reference |
|---|---|---|---|---|
| Ag (mg/L) | 0.0010 | Chronic Estimate | 1/10 Rainbow trout $LC_{50}$ | See text (Section 4.4.2) |
| Al (mg/L) | 0.50 | Chronic Estimate | 1/10 Rainbow trout $LC_{50}$ | |
| As (mg/L) | 1.3 | Chronic Estimate | 1/10 Rainbow trout $LC_{50}$ | |
| Be (mg/L) | 0.30 | Chronic Estimate | 1/10 Rainbow trout $LC_{50}$ | |
| Cd (mg/L) | 0.015 | Chronic Value | Early lifestage | U.S. EPA, 1984a |
| Co (mg/L) | No data | | | |
| Cr (mg/L) | 6.9 | $IC_{50}$ | Growth | Anderson et al., 1989 |
| Cu (mg/L) | 0.020 | Chronic Value | Lifecycle | U.S. EPA, 1980c |
| Fe (mg/L) | 1.5 | $EC_{50}$ | Hatchability | MOE, 1987 |
| Hg (ug/L) | 27 | Chronic Estimate | 1/10 Rainbow trout $LC_{50}$ | |
| Mn (mg/L) | 1.5 | Chronic Estimate | 1/2 Rainbow trout $LC_{50}$ | MOE, 1987 |
| Mo (mg/L) | 0.38 | Chronic Estimate | 1/2 Rainbow trout $LC_{50}$ | MOE, 1987 |
| $NH_3$ (mg/L)[a] | 0.13 | Chronic Value | Species mean | U.S. EPA, 1985a |
| Ni (mg/L) | 0.38 | Chronic Value | Equation (chronic) | U.S. EPA, 1980e |
| $NO_3$ (mg/L) | No data | | | |
| $NO_2$ (mg/L) | 5 | Maximum Acceptable Concentration | Warm water species | CCREM, 1987 |

## TABLE D.3: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO FATHEAD MINNOWS AS REPORTED IN THE LITERATURE (Cont'd)

| Chemical/ Element | Approximate Value | End-Point | Comment | Reference |
|---|---|---|---|---|
| Pb (mg/L) | 6 | Chronic Estimate | 1/2 Lowest fathead minnow $LC_{50}$ | MOE, 1987 |
| Se (mg/L) | 0.11 | Chronic Value | Early lifestage | U.S. EPA, 1980f |
| Sr (mg/L) | No data | | | |
| Sulphide (mg/L) | 0.005 | Chronic Value | Growth | Smith et al., 1976 |
| TRC (mg/L) | 0.017 | Chronic Value | Life cycle | U.S. EPA, 1985b |
| V (mg/L) | No data | | | |
| Zn (mg/L) | 0.11 | Chronic Value | Lifecycle; Hardness = 46 | U.S. EPA, 1980g |

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[a] Un-ionized.

TABLE D.4: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO CERIODAPHNIA AS REPORTED IN THE LITERATURE

| Chemical/ Element | Approximate Value | End-Point | Comment | Reference |
|---|---|---|---|---|
| Ag (mg/L) | 0.00017 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | See text (Section 4.4.2) |
| Al (mg/L) | 0.33 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| As (mg/L) | 0.53 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| Be (mg/L) | 0.79 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| Cd (mg/L) | 0.00012 | Chronic Estimate | 1/100 *Daphnia magna* LC$_{50}$ | |
| Co (mg/L) | 0.005 | Chronic Estimate | 1/2 *Daphnia magna* value | |
| Cr (mg/L) | 0.040 | Chronic Value | *C. reticulata* | U.S. EPA, 1984b |
| Cu (mg/L) | 0.0060 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| Fe (mg/L) | 0.6 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| Hg (ug/L) | 0.5 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| Mn (mg/L) | 15 | No effect | No effect on crustaceans, worms and insect larvae | McKee and Wolf, 1963 |
| $NH_3$ (mg/L) [a] | 0.30 | Chronic Value | Species mean | U.S. EPA, 1985a |
| Ni (mg/L) | 0.33 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |
| $NO_3$ (mg/L) | No data | | | |
| $NO_2$ (mg/L) | No data | | | |
| Pb (mg/L) | 0.045 | Chronic Estimate | 1/10 *Daphnia magna* LC$_{50}$ | |

## TABLE D.4: TOXICITY OF VARIOUS ELEMENTS/CHEMICALS TO CERIODAPHNIA AS REPORTED IN THE LITERATURE (Cont'd)

| Chemical/ Element | Approximate Value | End-Point | Comment | Reference |
|---|---|---|---|---|
| Se (mg/L) | 0.071 | Chronic Estimate | 1/10 *Daphnia magna* $LC_{50}$ | |
| Sr (mg/L) | 21 | Chronic Estimate | 1/2 *Daphnia magna* value | |
| Sulphide (mg/L) | No data | | | |
| TRC (mg/L) | No data | | | |
| V (mg/L) | No data | | | |
| Zn (mg/L) | 0.054 | Chronic Estimate | 1/10 *Daphnia magna* $LC_{50}$ | |

[a] Un-ionized.

# APPENDIX E

## Toxicity Test Results

TABLE E.1 EFFLUENT TOXICITY TEST RESULTS - BRACEBRIDGE

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 26.07.89 | Comp.1 | | 99 (81-100) | | 59 (50-70) | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 27.07.89 | Comp.2 | | NL | | 84 (70-100) | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 28.07.89 | Comp.3 | | NL | NL | 84 (70-100) | 84 (70-100) | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 29.07.89 | Comp.4 | | NL | | NL | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 12.12.89 | Comp.1 | | NL | | NL | | 30 | 50 | 39 | NL | 70 | 100 | 84 | NL |
| 13.12.89 | Comp.2 | | NL | | NL | | >100 | >100 | >100 | NL | 50 | 70 | 59 | 100* |
| 14.12.89 | Comp.3 | org. | NL | | NL | | 20 | 30 | 24 | NL | >100 | >100 | >100 | NL |
| 15.12.89 | Comp.4 | | NL | | NL | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |

NL - Not acutely lethal
( ) - Confidence interval
org. - Sample submitted for organics analysis
* - Confidence limits can not be calculated

TABLE E.2 EFFLUENT TOXICITY TEST RESULTS - HIGHLAND CREEK

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 22.03.89 | Comp.1 | | 71 (50-100) | 71 (50-100) | NL | NL | 30 | 50 | 39 | 58 (49-69) | 30 | 50 | 39 | NL |
| 23.03.89 | Comp.2 | org. | 71 (50-100) | | NL | | 50 | 100 | 71 | 73 (63-84) | 50 | 100 | 71 | NL |
| 24.03.89 | Comp.3 | | 71 (50-100) | | NL | | 30 | 50 | 39 | 81 (70-100) | 50 | 100 | 71 | NL |
| 25.03.89 | Comp.4 | | 67 (59-75) | | NL | | 30 | 50 | 39 | 62 (49-82) | 50 | 100 | 71 | 81 (59-173) |
| 22.03.89 | Grab 1 | | 39 (30-50) | 71 (50-100) | 31 (27-36) | NL | | | | | | | | |
| 23.03.89 | Grab 2 | | 71 (50-100) | | NL | | | | | | | | | |
| 24.03.89 | Grab 3 | | 71 (50-100) | 71 (50-100) | NL | NL | | | | | | | | |
| 25.03.89 | Grab 4 | | 71 (50-100) | 71 (50-100) | 34 (30-39) | >100 (40) | | | | | | | | |
| 07.06.89 | Comp.1 | org. | NL | | NL | | <10 | 10 | <10** | NL | 5 | 10 | 7 | *** |
| 08.06.89 | Comp.2 | | >100 (10) | | NL | | 30 | 50 | 39 | NL | 70 | 100 | 84 | 100* |
| 09.06.89 | Comp.3 | | NL | | NL | | 30 | 50 | 39 | NL | 30 | 50 | 39 | 32 (27-38) |
| 10.06.89 | Comp.4 | org. | NL | | 18 (13-23) | | <10 | 10 | <10** | NL | 1 | 2 | 1.4 | 5.9 (4.4-7.9) |
| 07.06.89 | Grab 1 | | >100 (10) | | NL | | | | | | | | | |
| 08.06.89 | Grab 2 | | >100 (20) | | NL | | | | | | | | | |
| 09.06.89 | Grab 3 | | >100 (10) | | 78 (72-85) | | | | | | | | | |
| 10.06.89 | Grab 4 | | >100 (10) | | 39 (30-50) | | | | | | | | | |

NL - Not acutely lethal
>100 ( ) - Less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
* - Confidence limits can not be calculated
** - Lowest Concentration Tested
*** - Invalid data

TABLE E.3 EFFLUENT TOXICITY TEST RESULTS - HUNTSVILLE

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 16.08.89 | Comp.1 | org. | 28 (25-32) | NL | 14 (10-20) | NL | 20 | 30 | 24 | NL | >100 | >100 | >100 | NL |
| 17.08.89 | Comp.2 | pH | 27 (24-30) | 78 (67-94) | >100 (40) | 42 (38-47) | >100 | >100 | >100 | NL | 70 | 100 | 84 | NL |
| 18.08.89 | Comp.3 | org. | 37 (34-40) | NL | 14 (10-20) | 84 (70-100) | 10 | 20 | 14 | NL | >100 | >100 | >100 | NL |
| 19.08.89 | Comp.4 | | 39 (30-50) | NL | 14 (10-20) | NL | 50 | 70 | 59 | NL | >100 | >100 | >100 | NL |
| 06.12.89 | Comp.1 | | 14 (10-20) | NL | 14 (10-20) | NL | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 07.12.89 | Comp.2 | | 21 (18-24) | NL | 7 (5-10) | NL | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 08.12.89 | Comp.3 | | 24 (20-30) | >100 (30) | 7 (5-10) | 54 (49-61) | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 09.12.89 | Comp.4 | org. | 28 (25-32) | 98* | 14 (10-20) | 66 (59-73) | 70 | 100 | 84 | NL | 30 | 50 | 39 | NL |

NL - Not acutely lethal
>100 ( ) - Less than 50% mortality: observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
pH - Sample pH adjusted to 6.0 prior to initiation of chronic tests
* - Confidence limits can not be calculated

TABLE E.4 EFFLUENT TOXICITY TEST RESULTS - LINDSAY

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 23.08.89 | Comp.1 | filt. | NL | | NL | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 24.08.89 | Comp.2 | filt. | NL | | NL | | 20 | 30 | 24 | NL | >100 | >100 | >100 | NL |
| 25.08.89 | Comp.3 | filt. | NL | | NL | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 26.08.89 | Comp.4 | filt. | NL | | NL | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 23.08.89 | Grab 1 | | >100 (20) | | NL | | | | | | | | | |
| 24.08.89 | Grab 2 | | NL | | NL | | | | | | | | | |
| 25.08.89 | Grab 3 | | NL | | NL | | | | | | | | | |
| 29.03.89 | Comp.1 | | 96* | | NL | | 50 | 100 | 71 | 67 (58-78) | 50 | 100 | 71 | NL |
| 30.03.89 | Comp.2 | org. | 63 (54-73) | | NL | | 50 | 100 | 71 | 70 (64-76) | 10 | 20 | 14 | NL |
| 31.03.89 | Comp.3 | | 71 (50-100) | | NL | | 30 | 50 | 39 | 100* | 50 | 100 | 71 | 75 (59-102) |
| 01.04.89 | Comp.4 | | 71 (50-100) | | >100 (10) | | 30 | 50 | 39 | 93 (77-144) | >100 | >100 | >100 | NL |
| 29.03.89 | Grab 1 | | 67 (59-75) | | NL | | | | | | | | | |
| 30.03.89 | Grab 2 | | 100* | | NL | | | | | | | | | |
| 31.03.89 | Grab 3 | | 71 (50-100) | | NL | | | | | | | | | |

NL - Not acutely lethal
>100 ( ) - less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
filt. - Sample filtered
* - Confidence limits can not be calculated

TABLE E.5 EFFLUENT TOXICITY TEST RESULTS - MIDLAND

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 19.07.89 | Comp.1 | | 50 (44-57) | 83 (81-85) | 19 (16-22) | 84 (70-100) | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 20.07.89 | Comp.2 | | 60 (40-52) | >100 (30) | 21 (18-24) | 63 (58-69) | 50 | 70 | 59 | 88 (70-156) | 50 | 70 | 59 | 67 (53-92) |
| 21.07.89 | Comp.3 | | 75 (68-83) | | 92* | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 22.07.89 | Comp.4 | | 84 (70-100) | >100 (20) | NL | NL | 70 | 100 | 84 | 100* | 30 | 50 | 39 | 86 (76-101. |
| 19.07.89 | Grab 1 | | 29 (24-35) | >100 (10) | 14 (10-20) | NL | | | | | | | | |
| 20.07.89 | Grab 2 | | 39 (30-50) | >100 (10) | 24 (20-30) | 98* | | | | | | | | |
| 21.07.89 | Grab 3 | | 31 (26-36) | NL | 14 (10-20) | NL | | | | | | | | |
| 21.07.89 | Grab 4 | | 68 (59-82) | 75 (65-90) | NL | NL | | | | | | | | |
| 21.07.89 | Grab 5 | | 73 (65-81) | 84 (70-100) | >100 (10) | NL | | | | | | | | |
| 21.07.89 | Grab 6 | | 71 (60-86) | 100 (84-100) | 75 (68-83) | NL | | | | | | | | |
| 10.01.90 | Comp.1 | | NL | | NL | | 50 | 70 | 59 | 98 (88-121) | 70 | 100 | 84 | NL |
| 11.01.90 | Comp.2 | org. | 66 (59-73) | | NL | | 10 | 20 | 14 | NL | 30 | 50 | 39 | 72 (63-82) |
| 12.01.90 | Comp.3 | org. | 81 (76-86) | | NL | | 70 | 100 | 84 | NL | 20 | 30 | 24 | 38 (32-45) |
| 13.01.90 | Comp.4 | | >100 (40) | | NL | | 70 | 100 | 84 | NL | 50 | 70 | 59 | 78 (69-91) |
| 10.01.90 | Grab 1 | | NL | | NL | | | | | | | | | |
| 11.01.90 | Grab 2 | | 87 (86-88) | | NL | | | | | | | | | |
| 11.01.90 | Grab 3 | | 97* | | NL | | | | | | | | | |
| 12.01.90 | Grab 4 | | 80 (71-96) | | NL | | | | | | | | | |
| 13.01.90 | Grab 5 | | >100 (30) | | NL | | | | | | | | | |
| 13.01.90 | Grab 6 | | >100 (20) | | NL | | | | | | | | | |

NL - Not acutely lethal
>100 ( ) - less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
* - Confidence limits can not be calculated

TABLE E.6 EFFLUENT TOXICITY TEST RESULTS - NORTH TORONTO

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | RAINBOW TROUT LC50 (%v/v) |  | DAPHNIA MAGNA LC50 (%v/v) |  | FATHEAD MINNOW |  |  |  | CERIODAPHNIA |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 15.03.89 | Comp.1 | NL | NL | NL | NL | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 16.03.89 | Comp.2 | NL | NL | NL | NL | 50 | 100 | 71 | NL | 30 | 50 | 39 | 94* |
| 17.03.89 | Comp.3 | NL | NL | NL | NL | >100 | >100 | >100 | NL | 50 | 100 | 71 | NL |
| 18.03.89 | Comp.4 | NL | NL | 67 (59-75) | NL | >100 | >100 | >100 | NL | 50 | 100 | 71 | NL |
| 14.06.89 | Comp.1 | 59 (50-70) | NL | 22 (19-25) | NL | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 15.06.89 | Comp.2 | 42 (38-47) | NL | 14 (10-20) | >100 (10) | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 16.06.89 | Comp.3 | 57 (52-61) | NL | 39 (30-50) | NL | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 17.06.89 | Comp.4 | >100 (40) | >100 (10) | 73 (65-81) | NL | <10 | 10 | <10 | NL | >100 | >100 | >100 | NL |

NL - Not acutely lethal
>100 ( ) - less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
* - Confidence limits can not be calculated

TABLE E.7 EFFLUENT TOXICITY TEST RESULTS - PERTH

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) As Received | RAINBOW TROUT LC50 (%v/v) Dechlorinated | DAPHNIA MAGNA LC50 (%v/v) As Received | DAPHNIA MAGNA LC50 (%v/v) Dechlorinated | FATHEAD MINNOW NOEC (%v/v) | FATHEAD MINNOW LOEC (%v/v) | FATHEAD MINNOW CHRONIC VALUE (%v/v) | FATHEAD MINNOW LC50 (%v/v) | CERIODAPHNIA NOEC (%v/v) | CERIODAPHNIA LOEC (%v/v) | CERIODAPHNIA CHRONIC VALUE (%v/v) | CERIODAPHNIA LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13.09.89 | Comp.1 | filt. | NL | | NL | | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 14.09.89 | Comp.2 | | NL | | NL | | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 15.09.89 | Comp.3 | | NL | | NL | | 30 | 50 | 39 | NL | >100 | >100 | >100 | NL |
| 16.09.89 | Comp.4 | | NL | | NL | | 50 | 70 | 59 | NL | >100 | >100 | >100 | NL |
| 13.09.89 | Grab 1 | | NL | | NL | | | | | | | | | |
| 14.09.89 | Grab 2 | | NL | | NL | | | | | | | | | |
| 15.09.89 | Grab 3 | | NL | | NL | | | | | | | | | |
| 21.02.90 | Comp.1 | | 54 (45-64) | | NL | | 30 | 50 | 39 | NL | 50 | 70 | 59 | NL |
| 22.02.90 | Comp.2 | org. | 98* | | NL | | 50 | 70 | 59 | NL | 20 | 30 | 24 | 31 (20-47) |
| 23.02.90 | Comp.3 | | 75 (68-83) | | NL | | 30 | 50 | 39 | NL | 30 | 50 | 39 | NL |
| 24.02.90 | Comp.4 | | 78 (72-85) | | NL | | 30 | 50 | 39 | NL | 30 | 50 | 39 | 24 (18-34) |
| 21.02.90 | Grab 1 | | 59 (52-67) | | NL | | | | | | | | | |
| 22.02.90 | Grab 2 | | 57* | | NL | | | | | | | | | |
| 23.02.90 | Grab 3 | | 18 (14-24) | | NL | | | | | | | | | |

NL - Not acutely lethal
( ) - Confidence interval
org. - Sample submitted for organics analysis
filt. - Sample filtered
* - Confidence limits can not be calculated

TABLE E.8 EFFLUENT TOXICITY TEST RESULTS - STRATFORD

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) As Received | RAINBOW TROUT LC50 (%v/v) Dechlorinated | DAPHNIA MAGNA LC50 (%v/v) As Received | DAPHNIA MAGNA LC50 (%v/v) Dechlorinated | FATHEAD MINNOW NOEC (%v/v) | FATHEAD MINNOW LOEC (%v/v) | FATHEAD MINNOW CHRONIC VALUE (%v/v) | FATHEAD MINNOW LC50 (%v/v) | CERIODAPHNIA NOEC (%v/v) | CERIODAPHNIA LOEC (%v/v) | CERIODAPHNIA CHRONIC VALUE (%v/v) | CERIODAPHNIA LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.07.89 | Comp.1 | | 63 (58-69) | | NL | | 20 | 30 | 24 | 58 (53-63) | 50 | 70 | 59 | NL |
| 13.07.89 | Comp.2 | org. | 75 (66-87) | | NL | | 70 | 100 | 84 | NL | 70 | 100 | 84 | 94 (80-196) |
| 14.07.89 | Comp.3 | org. | 74 (64-87) | | NL | | 30 | 50 | 39 | 97 (89-114) | 70 | 100 | 84 | NL |
| 15.07.89 | Comp.4 | | 51 (41-59) | | NL | | 30 | 50 | 39 | 87 (76-110) | 70 | 100 | 84 | NL |
| 14.02.90 | Comp.1 | | >100 (40) | | NL | | 50 | 70 | 59 | NL | 50 | 70 | 59 | NL |
| 15.02.90 | Comp.2 | | 87 (70-100) | | NL | | 50 | 70 | 59 | NL | 70 | 100 | 84 | NL |
| 16.02.90 | Comp.3 | org. | 84 (70-100) | | NL | | 10 | 20 | 14 | NL | 70 | 100 | 84 | NL |
| 17.02.90 | Comp.4 | org. | 84 (70-100) | | NL | | 70 | 100 | 84 | NL | 20 | 30 | 24 | 30 (25-39) |

NL - Not acutely lethal
>100 ( ) - less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis

TABLE E.9 EFFLUENT TOXICITY TEST RESULTS - WALKERTON

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | | RAINBOW TROUT LC50 (%v/v) | | DAPHNIA MAGNA LC50 (%v/v) | | FATHEAD MINNOW | | | | CERIODAPHNIA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | As Received | Dechlorinated | As Received | Dechlorinated | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) | NOEC (%v/v) | LOEC (%v/v) | CHRONIC VALUE (%v/v) | LC50 (%v/v) |
| 21.06.89 | Comp.1 | | ** | ** | NL | NL | >100 | >100 | >100 | NL | 50 | 70 | 59 | 77 (66-97) |
| 22.06.89 | Comp.2 | | >100 (20) | | NL | | >100 | >100 | >100 | NL | 50 | 70 | 59 | 94 (80-196 |
| 23.06.89 | Comp.3 | | NL | | NL | | >100 | >100 | >100 | NL | 70 | 100 | 84 | NL |
| 24.06.89 | Comp.4 | | NL | | NL | | >100 | >100 | >100 | NL | 70 | 100 | 84 | 100* |
| 17.01.90 | Comp.1 | org. | NL | | NL | | 30 | 50 | 39 | NL | 10 | 20 | 14 | 39 (31-50) |
| 18.01.90 | Comp.2 | org. | NL | | NL | | >100 | >100 | >100 | NL | 20 | 30 | 24 | 33 (24-41) |
| 19.01.90 | Comp.3 | | NL | | NL | | >100 | >100 | >100 | NL | 20 | 30 | 24 | 67 (53-84) |
| 20.01.90 | Comp.4 | | NL | | NL | | >100 | >100 | >100 | NL | 20 | 30 | 24 | 63 (49-80) |

NL - Not acutely lethal
>100 ( ) - less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
* - Confidence limits can not be calculated
** - invalid data

TABLE E.10 EFFLUENT TOXICITY TEST RESULTS - WALLACEBURG

| DATE COLLECTED (dd.mm.yy) | SAMPLE I.D. | RAINBOW TROUT LC50 (%v/v) As Received | RAINBOW TROUT LC50 (%v/v) Dechlorinated | DAPHNIA MAGNA LC50 (%v/v) As Received | DAPHNIA MAGNA LC50 (%v/v) Dechlorinated | FATHEAD MINNOW NOEC (%v/v) | FATHEAD MINNOW LOEC (%v/v) | FATHEAD MINNOW CHRONIC VALUE (%v/v) | FATHEAD MINNOW LC50 (%v/v) | CERIODAPHNIA NOEC (%v/v) | CERIODAPHNIA LOEC (%v/v) | CERIODAPHNIA CHRONIC VALUE (%v/v) | CERIODAPHNIA LC50 (%v/v) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.09.89 | Comp.1 | NL | >100 (20) | 81 (76-86) | NL | 20 | 30 | 24 | NL | >100 | >100 | >100 | NL |
| 07.09.89 | Comp.2 | NL | NL | NL | NL | 50 | 70 | 59 | NL | >100 | >100 | >100 | NL |
| 08.09.89 | Comp.3 | NL | | NL | | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 09.09.89 | Comp.4 | pH 84 (69-100) | | >100 (10) | | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 06.09.89 | Grab 1 | NL | | NL | | | | | | | | | |
| 07.09.89 | Grab 2 | NL | NL | NL | NL | | | | | | | | |
| 08.09.89 | Grab 3 | 84 (74-100) | NL | 59 (50-70) | NL | | | | | | | | |
| 09.09.89 | Grab 4 | 78 (72-85) | | NL | | | | | | | | | |
| 09.09.89 | Grab 5 | NL | | NL | | | | | | | | | |
| 09.09.89 | Grab 6 | NL | NL | 54 (48-60) | NL | | | | | | | | |
| 24.01.90 | Comp.1 | pH 57 (47-65) | 73 (66-80) | 66 (59-73) | NL | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 25.01.90 | Comp.2 | org.&pH42 (38-47) | 56 (47-65) | NL | NL | 70 | 100 | 84 | NL | 50 | 70 | 59 | 84 (63-170) |
| 26.01.90 | Comp.3 | pH 39 (30-50) | | NL | | 70 | 100 | 84 | NL | >100 | >100 | >100 | NL |
| 27.01.90 | Comp.4 | pH 58 (48-68) | 81 (76-86) | NL | NL | >100 | >100 | >100 | NL | >100 | >100 | >100 | NL |
| 24.01.90 | Grab 1 | 51 (45-57) | 78 (73-83) | 59 (50-70) | NL | | | | | | | | |
| 25.01.90 | Grab 2 | 44 (39-50) | 54 (49-61) | 24 (20-30) | NL | | | | | | | | |
| 26.01.90 | Grab 3 | 78 (72-85) | | NL | | | | | | | | | |
| 26.01.90 | Grab 4 | 59 (50-70) | | NL | | | | | | | | | |
| 26.01.90 | Grab 5 | 72 (64-82) | 58 (49-68) | NL | NL | | | | | | | | |
| 27.01.90 | Grab 6 | 37 (34-40) | 66 (59-73) | 14 (10-20) | NL | | | | | | | | |

NL - Not acutely lethal
>100 ( ) - Less than 50% mortality; observed percent mortality in parenthesis
( ) - Confidence interval
org. - Sample submitted for organics analysis
pH - Sample pH adjusted to 6.0 prior to initiation of chronic tests

# APPENDIX F

## Effluent Chemistry

TABLE F.1.1-a

## EFFLUENT CHEMICAL QUALITY - BRACEBRIDGE

| DATE: 1989 | JUL26 | JUL27 | JUL28 | JUL29 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 5.0 | 5.5 | 2.5 | 4.0 | 4.3 | 1.3 |
| VSS (mg/L) | 4.0 | 3.8 | 2.5 | 2.5 | 3.2 | 0.8 |
| Ammon (mg/L) | 6.10 | 5.08 | 3.85 | 1.25 | 4.07 | 2.09 |
| Nitrate (mg/L) | 2.70 | 2.55 | 2.80 | 5.55 | 3.40 | 1.44 |
| Nitrite (mg/L) | 0.010 | 0.025 | 0.020 | 0.005 | 0.015 | 0.009 |
| BOD (mg/L) | 3.2 | 2.6 | 2.5 | 0.7 | 2.3 | 1.1 |
| DOC (mg/L) | 8.5 | 8.0 | 8.5 | 8.0 | 8.3 | 0.3 |
| TRC (mg/L) | 0.08 | 0.02 * | 0.11 | 0.06 | 0.07 | 0.04 |
| Cu (mg/L) | 0.0025 * | 0.0038 | 0.0520 | 0.0025 * | 0.0152 | 0.0245 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0100 * | 0.0125 * | 0.0200 | 0.0300 | 0.0181 | 0.0090 |
| Zn (mg/L) | 0.0100 | 0.0200 | 0.0300 | 0.0300 | 0.0225 | 0.0096 |
| Fe (mg/L) | 0.1800 | 0.1800 | 0.3500 | 0.1400 | 0.2125 | 0.0936 |
| Mn (mg/L) | 0.1300 | 0.1300 | 0.1300 | 0.1400 | 0.1325 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.4100 | 0.4600 | 0.4900 | 0.3000 | 0.4150 | 0.0835 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 2.80 | 2.00 | 2.10 | 1.50 | 2.10 | 0.54 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/l) | 0.0050 * | 0.0200 | 0.0050 * | 0.0088 | 0.0097 | 0.0071 |
| Mg (mg/L) | 4.40 | 4.40 | 4.30 | 4.40 | 4.38 | 0.05 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.1100 | 0.1100 | 0.1000 | 0.1000 | 0.1050 | 0.0058 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.1-b

## EFFLUENT CHEMICAL QUALITY - BRACEBRIDGE

| DATE: 1989 | JUL26 | JUL27 | JUL28 | JUL29 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - FILTERED** | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0025 * | 0.0043 | 0.0130 | 0.0070 | 0.0067 | 0.0046 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0125 | 0.0500 | 0.0200 | 0.0219 | 0.0197 |
| Zn (mg/L) | 0.0300 | 0.0100 | 0.0700 | 0.0300 | 0.0350 | 0.0252 |
| Fe (mg/L) | 0.0870 | 0.0950 | 0.1200 | 0.1000 | 0.1005 | 0.0141 |
| Mn (mg/L) | 0.1300 | 0.1300 | 0.1300 | 0.1400 | 0.1325 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1300 | 0.1100 | 0.1300 | 0.1000 | 0.1175 | 0.0150 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 3.10 | 1.85 | 1.50 | 1.40 | 1.96 | 0.78 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0200 | 0.0275 | 0.0025 * | 0.0025 * | 0.0131 | 0.0126 |
| Hg (ug/L) | 0.0200 | 0.0025 | 0.0200 | 0.0200 | 0.0156 | 0.0088 |
| Mg (mg/L) | 4.70 | 4.35 | 4.30 | 4.40 | 4.44 | 0.18 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.1200 | 0.1100 | 0.1000 | 0.1000 * | 0.1075 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.2-a

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | JUN7 | JUN8 | JUN9 | JUN10 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 24.0 | 18.5 | 37.4 | 27.9 | 27.0 | 8.0 |
| VSS (mg/L) | 20.9 | 15.1 | 29.4 | 21.7 | 21.8 | 5.9 |
| Ammon (mg/L) | 11.00 | 11.75 | 12.60 | 10.70 | 11.51 | 0.85 |
| Nitrate (mg/L) | 4.60 | 6.10 | 3.05 | 5.85 | 4.90 | 1.40 |
| Nitrite (mg/L) | 2.600 | 3.800 | 2.000 | 3.700 | 3.025 | 0.873 |
| BOD (mg/L) | 36.0 | 49.9 | 43.3 | 41.4 | 42.7 | 5.7 |
| DOC (mg/L) | 12.5 | 12.3 | 11.0 | 11.5 | 11.8 | 0.7 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0300 | 0.0230 | 0.0900 | 0.0400 | 0.0458 | 0.0303 |
| Ni (mg/L) | 0.0390 | 0.0380 | 0.0400 | 0.0300 | 0.0368 | 0.0046 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0200 | 0.0050 * | 0.0088 | 0.0075 |
| Zn (mg/L) | 0.0800 | 0.0800 | 0.1500 | 0.0900 | 0.1000 | 0.0337 |
| Fe (mg/L) | 1.9000 | 1.7500 | 4.3800 | 2.5000 | 2.6325 | 1.2092 |
| Mn (mg/L) | 0.6800 | 0.9000 | 0.7800 | 0.6500 | 0.7525 | 0.1130 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.2200 | 0.1600 | 0.5100 | 0.2100 | 0.2750 | 0.1589 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 209.20 | 184.30 | 195.70 | 194.70 | 195.98 | 10.21 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0085 | 0.0080 | 0.0300 | 0.0100 | 0.0141 | 0.0106 |
| Hg (ug/L) | 0.0400 | 0.0850 | 0.2500 | 0.0400 | 0.1038 | 0.0998 |
| Mg (mg/L) | 10.00 | 10.50 | 9.80 | 9.80 | 10.03 | 0.33 |
| Mo (mg/L) | 0.0080 | 0.0090 | 0.0100 * | 0.0100 * | 0.0093 | 0.0010 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2100 | 0.2000 | 0.2000 | 0.2000 | 0.2025 | 0.0050 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0300 * | 0.0100 * | 0.0150 | 0.0100 |

* reported concentration = MDL/2

TABLE F.1.2-b

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | JUN7 | JUN8 | JUN9 | JUN10 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0240 | 0.0215 | 0.0400 | 0.0240 | 0.0274 | 0.0085 |
| Ni (mg/L) | 0.0370 | 0.0390 | 0.0300 | 0.0340 | 0.0350 | 0.0039 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.1000 | 0.0950 | 0.1300 | 0.1000 | 0.1063 | 0.0160 |
| Fe (mg/L) | 0.0810 | 0.1140 | 0.0900 | 0.0520 | 0.0843 | 0.0256 |
| Mn (mg/L) | 0.6400 | 0.9000 | 0.7400 | 0.6500 | 0.7325 | 0.1204 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0350 | 0.0500 | 0.0100 * | 0.0263 | 0.0197 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 | 0.0063 | 0.0025 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 207.90 | 186.50 | 192.90 | 156.70 | 186.00 | 21.49 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0060 | 0.0025 * | 0.0034 | 0.0018 |
| Cr (mg/L) | 0.0080 | 0.0060 | 0.0025 * | 0.0025 * | 0.0048 | 0.0027 |
| Hg (ug/L) | 0.2300 | 0.4300 | 0.1500 | 0.0400 | 0.2125 | 0.1646 |
| Mg (mg/L) | 10.00 | 10.50 | 9.60 | 10.00 | 10.03 | 0.37 |
| Mo (mg/L) | 0.0080 | 0.0053 | 0.0100 | 0.0110 | 0.0086 | 0.0025 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0088 | 0.0075 |
| Sr (mg/L) | 0.2100 | 0.2100 | 0.2000 | 0.1900 | 0.2025 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.2-c

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | JUN7 | JUN8 | JUN9 | JUN10 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **GRAB - NON-FILTERED** | | | | | | |
| SS (mg/L) | 16.8 | NA | 25.0 | 19.4 | 20.4 | 4.2 |
| VSS (mg/L) | 15.3 | NA | 19.7 | 14.5 | 16.5 | 2.8 |
| Ammon (mg/L) | 11.30 | 15.90 | 10.50 | NA | 12.57 | 2.91 |
| Nitrate (mg/L) | 4.95 | 1.10 | 5.75 | NA | 3.93 | 2.49 |
| Nitrite (mg/L) | 2.650 | 0.655 | 3.900 | NA | 2.402 | 1.637 |
| BOD (mg/L) | 30.4 | 89.1 | 48.7 | 32.6 | 50.2 | 27.2 |
| DOC (mg/L) | 11.5 | 14.0 | 12.5 | 8.0 | 11.5 | 2.5 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.08 | 0.005 * | 0.024 | 0.037 |
| Cu (mg/L) | 0.0200 | 0.3000 | 0.0300 | 0.0250 | 0.0938 | 0.1376 |
| Ni (mg/L) | 0.0270 | 0.0360 | 0.0300 | 0.0370 | 0.0325 | 0.0048 |
| Pb (mg/L) | 0.0050 * | 0.0600 | 0.0050 * | 0.0050 * | 0.0188 | 0.0275 |
| Zn (mg/L) | 0.0600 | 0.3800 | 0.0600 | 0.1000 | 0.1500 | 0.1545 |
| Fe (mg/L) | 1.7000 | 12.0000 | 2.1000 | 1.4000 | 4.3000 | 5.1413 |
| Mn (mg/L) | 0.9300 | 1.0600 | 0.5300 | 0.9100 | 0.8575 | 0.2282 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1100 | 1.7400 | 0.1600 | 0.1900 | 0.5500 | 0.7940 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 216.60 | 217.10 | 198.10 | 166.50 | 199.58 | 23.76 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0070 | 0.0860 | 0.0100 | 0.0080 | 0.0278 | 0.0389 |
| Hg (ug/L) | 0.0200 | 0.2200 | 0.0400 | 0.0300 | 0.0775 | 0.0954 |
| Mg (mg/L) | 10.00 | 11.00 | 9.55 | 11.00 | 10.39 | 0.73 |
| Mo (mg/L) | 0.0090 | 0.0100 | 0.0110 | 0.0090 | 0.0098 | 0.0010 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0088 | 0.0075 |
| Sr (mg/L) | 0.2200 | 0.2200 | 0.2000 | 0.2100 | 0.2125 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0700 | 0.0100 * | 0.0100 * | 0.0250 | 0.0300 |

* reported concentration = MDL/2

TABLE F.1.2-d

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | JUN7 | JUN8 | JUN9 | JUN10 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0270 | 0.0400 | 0.0300 | 0.0190 | 0.0290 | 0.0087 |
| Ni (mg/L) | 0.0210 | 0.0300 | 0.0200 | 0.0370 | 0.0270 | 0.0080 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0900 | 0.1900 | 0.0800 | 0.1000 | 0.1150 | 0.0507 |
| Fe (mg/L) | 0.0820 | 0.1300 | 0.0600 | 0.0540 | 0.0815 | 0.0345 |
| Mn (mg/L) | 0.8800 | 0.8900 | 0.5100 | 0.8200 | 0.7750 | 0.1794 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0400 | 0.0100 * | 0.0100 * | 0.0500 | 0.0275 | 0.0206 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 215.50 | 201.40 | 194.90 | 152.00 | 190.95 | 27.35 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0060 | 0.0025 * | 0.0025 * | 0.0034 | 0.0018 |
| Hg (ug/L) | 0.1900 | 0.0700 | 0.0700 | 0.0400 | 0.0925 | 0.0665 |
| Mg (mg/L) | 10.00 | 9.99 | 9.50 | 11.00 | 10.12 | 0.63 |
| Mo (mg/L) | 0.0070 | 0.0070 | 0.0100 | 0.0090 | 0.0083 | 0.0015 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0088 | 0.0075 |
| Sr (mg/L) | 0.2100 | 0.2100 | 0.2000 | 0.1900 | 0.2025 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.3-a

## EFFLUENT CHEMICAL QUALITY - HUNTSVILLE

COMPOSITES - NON-FILTERED

| DATE: 1989 | AUG16 | AUG17 | AUG18 | AUG19 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| SS (mg/L) | 9.0 | 8.0 | 7.0 | 8.5 | 8.1 | 0.9 |
| VSS (mg/L) | 7.0 | 6.0 | 5.0 | 6.0 | 6.0 | 0.8 |
| Ammon (mg/L) | 15.70 | 16.20 | 15.70 | 16.50 | 16.03 | 0.39 |
| Nitrate (mg/L) | 0.45 | 0.35 | 0.35 | 0.20 | 0.34 | 0.10 |
| Nitrite (mg/L) | 0.080 | 0.065 | 0.070 | 0.035 | 0.063 | 0.019 |
| BOD (mg/L) | 6.6 | 2.6 | 2.5 | 4.5 | 4.1 | 1.9 |
| DOC (mg/L) | 11.0 | 10.0 | 10.0 | 9.5 | 10.1 | 0.6 |
| TRC (mg/L) | 0.51 | 0.52 | 0.58 | 0.49 | 0.53 | 0.04 |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.2800 | 0.0738 | 0.1375 |
| Pb (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Zn (mg/L) | 0.0300 | 0.0250 | 0.0100 | 0.0200 | 0.0213 | 0.0085 |
| Fe (mg/L) | 0.7300 | 0.5900 | 0.0890 | 0.6200 | 0.5073 | 0.2853 |
| Mn (mg/L) | 0.1400 | 0.1400 | 0.0050 * | 0.1300 | 0.1038 | 0.0660 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 1.3000 | 1.0400 | 0.0100 * | 0.8500 | 0.8000 | 0.5580 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 22.03 | 21.68 | 5.68 | 21.30 | 17.67 | 8.00 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0130 | 0.0051 | 0.0052 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0380 | 0.0114 | 0.0178 |
| Hg (ug/L) | 0.0300 | 0.0300 | 0.0200 | 0.0300 | 0.0275 | 0.0050 |
| Mg (mg/L) | 4.30 | 4.15 | 1.50 | 4.20 | 3.54 | 1.36 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.1000 | 0.1000 | 0.0100 | 0.0900 | 0.0750 | 0.0436 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.3-b

## EFFLUENT CHEMICAL QUALITY - HUNTSVILLE

COMPOSITES - FILTERED

| DATE: 1989 | AUG16 | AUG17 | AUG18 | AUG19 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0100 | 0.0068 | 0.0100 | 0.0060 | 0.0082 | 0.0042 |
| Ni (mg/L) | 0.0050 * | 0.0115 | 0.0050 * | 0.0050 * | 0.0066 | 0.0047 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0088 | 0.0087 |
| Zn (mg/L) | 0.0900 | 0.0550 | 0.0300 | 0.0300 | 0.0513 | 0.0382 |
| Fe (mg/L) | 0.3300 | 0.3700 | 0.2600 | 0.1600 | 0.2800 | 0.1698 |
| Mn (mg/L) | 0.1400 | 0.1500 | 0.1300 | 0.1200 | 0.1350 | 0.0695 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0250 |
| Al (mg/L) | 0.2400 | 0.2200 | 0.1600 | 0.1300 | 0.1875 | 0.1094 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0025 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0025 |
| Ca (mg/L) | 22.31 | 26.48 | 21.74 | 19.32 | 22.46 | 11.73 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0025 |
| Co (mg/L) | 0.0025 * | 0.0048 | 0.0025 * | 0.0025 * | 0.0031 | 0.0020 |
| Cr (mg/L) | 0.0050 | 0.0053 | 0.0080 | 0.0080 | 0.0066 | 0.0033 |
| Hg (ug/L) | 0.0500 | 0.0550 | 0.0300 | 0.0300 | 0.0413 | 0.0250 |
| Mg (mg/L) | 4.30 | 4.50 | 4.30 | 3.90 | 4.25 | 2.13 |
| Mo (mg/L) | 0.0025 * | 0.2480 | 0.0025 * | 0.0025 * | 0.0639 | 0.1232 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 | 0.0063 | 0.0041 |
| Sr (mg/L) | 0.1000 | 0.1100 | 0.0900 | 0.0900 | 0.0975 | 0.0507 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0050 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.4-a

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | AUG23 | AUG24 | AUG25 | AUG26 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 60.5 | 33.0 | 21.0 | 18.0 | 33.1 | 19.4 |
| VSS (mg/L) | 33.0 | 25.5 | 22.5 | 18.0 | 24.8 | 6.3 |
| Ammon (mg/L) | 1.55 | 1.53 | 1.65 | 1.75 | 1.62 | 0.10 |
| Nitrate (mg/L) | 0.15 | 0.23 | 0.25 | 0.25 | 0.22 | 0.05 |
| Nitrite (mg/L) | 0.150 | 0.233 | 0.210 | 0.160 | 0.188 | 0.040 |
| BOD (mg/L) | 21.8 | 18.6 | 18.6 | 9.3 | 17.1 | 5.4 |
| DOC (mg/L) | 14.0 | 13.8 | 14.0 | 14.5 | 14.1 | 0.3 |
| Sulphide (mg/L) | 0.025 * | 0.025 * | 0.025 * | 0.025 * | 0.025 | 0.000 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0038 | 0.0025 * | 0.0050 | 0.0035 | 0.0012 |
| Ni (mg/L) | 0.0140 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0073 | 0.0045 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0050 * | 0.0125 | 0.0200 | 0.0050 * | 0.0106 | 0.0072 |
| Fe (mg/L) | 0.1300 | 0.5800 | 0.4000 | 0.0100 | 0.2800 | 0.2581 |
| Mn (mg/L) | 0.0400 | 0.0400 | 0.0500 | 0.0400 | 0.0425 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1000 | 0.1150 | 0.0600 | 0.0600 | 0.0838 | 0.0281 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 47.94 | 47.81 | 53.00 | 55.00 | 50.94 | 3.63 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0200 | 0.0050 * | 0.0200 | 0.0125 | 0.0087 |
| Mg (mg/L) | 11.00 | 10.50 | 11.00 | 10.00 | 10.63 | 0.48 |
| Mo (mg/L) | 0.0360 | 0.0330 | 0.0460 | 0.0350 | 0.0375 | 0.0058 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0200 | 0.0200 | 0.0175 | 0.0050 |
| Sr (mg/L) | 0.1900 | 0.1900 | 0.2200 | 0.2100 | 0.2025 | 0.0150 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.4-b

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | AUG23 | AUG24 | AUG25 | AUG26 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0070 | 0.0100 | 0.0025 * | 0.0025 * | 0.0055 | 0.0037 |
| Ni (mg/L) | 0.0110 | 0.0050 | 0.0050 * | 0.0050 * | 0.0065 | 0.0030 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0075 | 0.0029 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0200 | 0.0200 | 0.0250 | 0.0058 |
| Fe (mg/L) | 0.0100 * | 0.2550 | 0.0100 * | 0.0100 * | 0.0713 | 0.1225 |
| Mn (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0100 | 0.0075 | 0.0029 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0500 | 0.0400 | 0.0100 * | 0.0100 * | 0.0275 | 0.0206 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 45.05 | 45.66 | 54.00 | 52.00 | 49.18 | 4.50 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0960 | 0.0025 * | 0.0025 * | 0.0259 | 0.0467 |
| Cr (mg/L) | 0.0025 * | 0.0100 * | 0.0025 * | 0.0025 * | 0.0044 | 0.0038 |
| Hg (ug/L) | 0.0400 | 0.0125 | 0.0600 | 0.0400 | 0.0381 | 0.0195 |
| Mg (mg/L) | 10.00 | 9.90 | 12.00 | 12.00 | 10.98 | 1.18 |
| Mo (mg/L) | 0.0320 | 0.0310 | 0.0380 | 0.0420 | 0.0358 | 0.0052 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0200 | 0.0200 | 0.0175 | 0.0050 |
| Sr (mg/L) | 0.1800 | 0.1800 | 0.2200 | 0.2300 | 0.2025 | 0.0263 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.4-c

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | AUG23 | AUG24 | AUG25 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| **GRAB - NON-FILTERED** | | | | | |
| SS (mg/L) | 24.5 | 23.0 | 19.0 | 22.2 | 2.8 |
| VSS (mg/L) | 21.0 | 20.5 | 16.0 | 19.2 | 2.8 |
| Ammon (mg/L) | 1.50 | 1.58 | 1.40 | 1.49 | 0.09 |
| Nitrate (mg/L) | 0.20 | 0.25 | 0.45 | 0.30 | 0.13 |
| Nitrite (mg/L) | 0.185 | 0.255 | 0.360 | 0.267 | 0.088 |
| BOD (mg/L) | 18.8 | 19.9 | 21.0 | 19.9 | 1.1 |
| DOC (mg/L) | 14.0 | 13.5 | 14.0 | 13.8 | 0.3 |
| Sulphide (mg/L) | 0.025 * | 0.025 * | 0.025 * | 0.025 | 0.000 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0140 | 0.0063 | 0.0066 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Fe (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |
| Mn (mg/L) | 0.0300 | 0.0400 | 0.0400 | 0.0367 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0700 | 0.0950 | 0.0800 | 0.0817 | 0.0126 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 44.44 | 48.57 | 52.00 | 48.34 | 3.79 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Mg (mg/L) | 10.00 | 10.50 | 12.00 | 10.83 | 1.04 |
| Mo (mg/L) | 0.3500 | 0.0330 | 0.0330 | 0.1387 | 0.1830 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0200 | 0.0167 | 0.0058 |
| Sr (mg/L) | 0.1800 | 0.1800 | 0.2100 | 0.1900 | 0.0173 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.4-d

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | AUG23 | AUG24 | AUG25 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | |
| SS (mg/L) | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | | |
| Cu (mg/L) | 0.0070 | 0.0048 | 0.0025 * | 0.0048 | 0.0023 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0067 | 0.0029 |
| Zn (mg/L) | 0.0200 | 0.0200 | 0.0300 | 0.0233 | 0.0058 |
| Fe (mg/L) | 0.0640 | 0.0640 | 0.4200 | 0.1827 | 0.2055 |
| Mn (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0067 | 0.0029 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0400 | 0.0400 | 0.0200 | 0.0333 | 0.0115 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 44.48 | 46.34 | 52.00 | 47.61 | 3.92 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0060 | 0.0130 | 0.0025 * | 0.0072 | 0.0053 |
| Hg (ug/L) | | 0.0200 | 0.0600 | 0.0400 | 0.0283 |
| Mg (mg/L) | 10.00 | 10.00 | 12.00 | 10.67 | 1.15 |
| Mo (mg/L) | 0.0390 | 0.0330 | 0.0370 | 0.0363 | 0.0031 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0200 | 0.0167 | 0.0058 |
| Sr (mg/L) | 0.1800 | 0.1800 | 0.2100 | 0.1900 | 0.0173 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.5-a

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| DATE: 1989 | JUL19 | JUL20 | JUL21 | JUL22 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 6.0 | 5.3 | 6.0 | 11.5 | 7.2 | 2.9 |
| VSS (mg/L) | 4.5 | 3.8 | 4.5 | 3.0 | 4.0 | 0.7 |
| Ammon (mg/L) | 14.00 | 9.50 | 9.35 | 17.70 | 12.64 | 4.01 |
| Nitrate (mg/L) | 0.35 | 0.55 | 0.15 | 0.60 | 0.41 | 0.21 |
| Nitrite (mg/L) | 0.155 | 0.540 | 0.125 | 0.055 | 0.219 | 0.218 |
| BOD (mg/L) | 8.0 | 8.0 | 8.7 | 7.1 | 8.0 | 0.7 |
| DOC (mg/L) | 6.0 | 4.8 | 5.0 | 4.0 | 5.0 | 0.8 |
| TRC (mg/L) | 0.38 | 0.43 | 0.01 * | 0.21 | 0.26 | 0.19 |
| Cu (mg/L) | 0.0070 | 0.0025 * | 0.0060 | 0.0025 * | 0.0045 | 0.0023 |
| Ni (mg/L) | 0.1200 | 0.0725 | 0.2100 | 0.2400 | 0.1606 | 0.0778 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0700 | 0.0225 | 0.0600 | 0.0500 | 0.0506 | 0.0205 |
| Fe (mg/L) | 0.4800 | 0.2350 | 0.4600 | 0.4100 | 0.3963 | 0.1115 |
| Mn (mg/L) | 0.0500 | 0.0275 | 0.1000 | 0.0500 | 0.0569 | 0.0306 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1700 | 0.1050 | 0.1200 | 0.1300 | 0.1313 | 0.0278 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.14 | 6.10 | 0.12 | 3.80 | 2.54 | 2.94 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0060 | 0.0025 * | 0.0080 | 0.0060 | 0.0056 | 0.0023 |
| Cr (mg/L) | 0.0050 | 0.0025 * | 0.0050 | 0.0070 | 0.0049 | 0.0018 |
| Hg (ug/L) | 0.0400 | 0.0250 | 0.0200 | 0.1200 | 0.0513 | 0.0466 |
| Mg (mg/L) | 14.00 | 13.00 | 13.00 | 13.00 | 13.25 | 0.50 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2200 | 0.0975 | 0.1800 | 0.1600 | 0.1644 | 0.0511 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.5-b

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| DATE: 1989 | JUL19 | JUL20 | JUL21 | JUL22 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0080 | 0.0025 * | 0.0070 | 0.0025 * | 0.0050 | 0.0029 |
| Ni (mg/L) | 0.1200 | 0.0675 | 0.2000 | 0.2300 | 0.1544 | 0.0742 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0700 | 0.0175 | 0.0600 | 0.0300 | 0.0444 | 0.0247 |
| Fe (mg/L) | 0.0410 | 0.0100 * | 0.0330 | 0.0100 * | 0.0235 | 0.0159 |
| Mn (mg/L) | 0.0500 | 0.0225 | 0.0500 | 0.0400 | 0.0406 | 0.0130 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0700 | 0.0550 | 0.0600 | 0.1100 | 0.0738 | 0.0250 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.14 | 3.00 | 0.10 | 4.20 | 1.86 | 2.07 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0060 | 0.0025 * | 0.0100 | 0.0060 | 0.0061 | 0.0031 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0300 | 0.0400 | 0.0900 | 0.0800 | 0.0600 | 0.0294 |
| Mg (mg/L) | 14.00 | 13.00 | 13.00 | 13.00 | 13.25 | 0.50 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2300 | 0.0925 | 0.1800 | 0.1600 | 0.1656 | 0.0569 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.5-c

## EFFLUENT CHEMICAL QUALITY - MIDLAND

|  |  | 1 PM | 7 PM | MIDNITE | 8 AM |  |  |
|---|---|---|---|---|---|---|---|
| DATE: 1989 JUL19 | JUL20 | JUL21 | JUL21 | JUL21 | JUL22 | AVG. | STD.DV. |

| DATE: 1989 | JUL19 | JUL20 | 1 PM<br>JUL21 | 7 PM<br>JUL21 | MIDNITE<br>JUL21 | 8 AM<br>JUL22 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|---|---|
| GRAB - NON-FILTERED |  |  |  |  |  |  |  |  |
| SS (mg/L) | 5.5 | 6.0 | 6.0 | 6.0 | 5.5 | 8.5 | 6.3 | 1.1 |
| VSS (mg/L) | 4.0 | 4.0 | 4.0 | 5.5 | 3.5 | 1.3 | 3.7 | 1.4 |
| Ammon (mg/L) | 10.30 | 9.50 | 7.25 | 9.35 | 9.30 | 22.80 | 11.42 | 5.67 |
| Nitrate (mg/L) | 0.35 | 0.55 | 0.85 | 0.55 | 0.35 | 0.60 | 0.54 | 0.19 |
| Nitrite (mg/L) | 0.200 | 7.600 | 0.360 | 0.370 | 0.265 | 0.390 | 1.531 | 2.974 |
| BOD (mg/L) | 1.4 | 4.8 | 2.6 | 8.4 | 6.9 | 6.6 | 5.1 | 2.7 |
| DOC (mg/L) | 4.5 | 4.5 | 5.0 | 5.0 | 5.5 | 4.0 | 4.8 | 0.5 |
| TRC (mg/L) | 0.56 | 0.48 | 0.57 | 0.22 | 0.32 | 0.20 | 0.39 | 0.17 |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Ni (mg/L) | 0.0750 | 0.1300 | 0.2000 | 0.2300 | 0.2600 | 0.2000 | 0.1825 | 0.0681 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0700 | 0.0600 | 0.0500 | 0.0300 | 0.0300 | 0.0400 | 0.0467 | 0.0163 |
| Fe (mg/L) | 0.3900 | 0.4150 | 0.4200 | 0.3900 | 0.3500 | 0.2900 | 0.3758 | 0.0488 |
| Mn (mg/L) | 0.0500 | 0.0500 | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0450 | 0.0055 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1300 | 0.1700 | 0.1200 | 0.2500 | 0.1400 | 0.1300 | 0.1567 | 0.0489 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.1300 | 3.20 | 0.08 | 4.00 | 4.60 | 4.30 | 2.72 | 2.08 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0053 | 0.0090 | 0.0080 | 0.0110 | 0.0100 | 0.0076 | 0.0032 |
| Cr (mg/L) | 0.0025 * | 0.0043 | 0.0060 | 0.0025 * | 0.0120 | 0.0070 | 0.0057 | 0.0036 |
| Hg (ug/L) | 0.0200 | 0.0300 | 0.0050 * | 0.0050 * | 0.0200 | 0.0050 * | 0.0142 | 0.0107 |
| Mg (mg/L) | 13.0000 | 13.00 | 13.00 | 13.00 | 13.00 | 13.00 | 13.00 | 0.00 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2200 | 0.1800 | 0.1600 | 0.1600 | 0.1500 | 0.1600 | 0.1717 | 0.0256 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.5-d

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| DATE: 1989 | JUL19 | JUL20 | 1 PM JUL21 | 7 PM JUL21 | MIDNITE JUL21 | 8 AM JUL22 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0070 | 0.0025 * | 0.0050 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0037 | 0.0019 |
| Ni (mg/L) | 0.0770 | 0.1250 | 0.1900 | 0.2200 | 0.2700 | 0.1920 | 0.1790 | 0.0687 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0075 | 0.0061 |
| Zn (mg/L) | 0.0700 | 0.0350 | 0.0500 | 0.0300 | 0.0300 | 0.0200 | 0.0392 | 0.0180 |
| Fe (mg/L) | 0.0350 | 0.0180 | 0.0210 | 0.0100 * | 0.2200 | 0.0100 * | 0.0523 | 0.0827 |
| Mn (mg/L) | 0.0500 | 0.0450 | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0442 | 0.0049 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1000 | 0.0800 | 0.0700 | 0.1300 | 0.0900 | 0.0900 | 0.0933 | 0.0207 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.12 | 3.50 | 0.10 | 3.90 | 4.40 | | 2.40 | 2.12 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0060 | 0.0025 * | 0.0090 | 0.0090 | 0.0110 | 0.0025 * | 0.0067 | 0.0036 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0080 | 0.0025 * | 0.0034 | 0.0022 |
| Hg (ug/L) | 0.0200 | 0.0600 | 0.0600 | 0.0400 | 0.0400 | 0.0600 | 0.0467 | 0.0163 |
| Mg (mg/L) | 14.00 | 13.00 | 13.00 | 13.00 | 13.00 | 12.89 | 13.15 | 0.42 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 * | 0.0058 | 0.0020 |
| Sr (mg/L) | 0.2200 | 0.2000 | 0.1600 | 0.1500 | 0.1600 | 0.1600 | 0.1750 | 0.0281 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.6-a

## EFFLUENT CHEMICAL QUALITY - NORTH TORONTO

| DATE: 1989 | JUN14 | JUN15 | JUN16 | JUN17 | AVG. | STD.DEV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 8.3 | 4.1 | 6.9 | 15.1 | 8.6 | 4.7 |
| VSS (mg/L) | 5.6 | 2.2 | 1.4 | 11.4 | 5.2 | 4.5 |
| Ammon (mg/L) | 4.70 | 4.08 | 2.70 | 2.45 | 3.48 | 1.08 |
| Nitrate (mg/L) | 14.00 | 14.55 | 15.50 | 13.80 | 14.46 | 0.76 |
| Nitrite (mg/L) | 0.580 | 0.530 | 0.435 | 0.475 | 0.505 | 0.063 |
| BOD (mg/L) | 3.4 | 4.9 | 4.1 | 5.1 | 4.4 | 0.8 |
| DOC (mg/L) | 6.0 | 5.8 | 5.5 | 5.6 | 5.7 | 0.2 |
| TRC (mg/L) | 0.33 | 0.34 | 0.29 | 0.27 | 0.31 | 0.03 |
| | | | | | | |
| Cu (mg/L) | 0.0130 | 0.0130 | 0.0110 | 0.0100 | 0.0118 | 0.0015 |
| Ni (mg/L) | 0.0170 | 0.0175 | 0.0120 | 0.0050 * | 0.0129 | 0.0058 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0200 | 0.0200 | 0.0200 | 0.0225 | 0.0050 |
| Fe (mg/L) | 0.7400 | 1.1200 | 0.7700 | 0.9600 | 0.8975 | 0.1775 |
| Mn (mg/L) | 0.0600 | 0.0700 | 0.0700 | 0.0700 | 0.0675 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0300 | 0.0100 * | 0.0800 | 0.0100 * | 0.0325 | 0.0330 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 173.80 | 176.40 | 176.20 | 169.00 | 173.85 | 3.44 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0600 | 0.0400 | 0.0300 | 0.0300 | 0.0400 | 0.0141 |
| Mg (mg/L) | 10.00 | 10.00 | 11.00 | 10.20 | 10.30 | 0.48 |
| Mo (mg/L) | 0.0200 | 0.0170 | 0.0170 | 0.0210 | 0.0188 | 0.0021 |
| Se (mg/L) | 0.0200 | 0.0100 | 0.0050 * | 0.0050 * | 0.0100 | 0.0071 |
| Sr (mg/L) | 0.2000 | 0.2000 | 0.2200 | 0.2000 | 0.2050 | 0.0100 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.6-b

## EFFLUENT CHEMICAL QUALITY - NORTH TORONTO

| DATE: 1989 | JUN14 | JUN15 | JUN16 | JUN17 | AVG. | STD.DEV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0130 | 0.0950 | 0.0100 | 0.0100 | 0.0320 | 0.0420 |
| Ni (mg/L) | 0.0150 | 0.0130 | 0.0050 * | 0.0050 * | 0.0095 | 0.0053 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0400 | 0.0200 | 0.0200 | 0.0200 | 0.0250 | 0.0100 |
| Fe (mg/L) | 0.0870 | 0.0300 | 0.0100 * | 0.2100 | 0.0843 | 0.0900 |
| Mn (mg/L) | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0300 | 0.0150 | 0.0100 |
| As (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 186.20 | 173.70 | 174.50 | 172.00 | 176.60 | 6.48 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.0300 | 0.0300 | 0.0200 | 0.0300 | 0.0082 |
| Mg (mg/L) | 11.00 | 10.50 | 10.60 | 9.49 | 10.40 | 0.64 |
| Mo (mg/L) | 0.0210 | 0.0170 | 0.0160 | 0.0190 | 0.0183 | 0.0022 |
| Se (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0088 | 0.0075 |
| Sr (mg/L) | 0.0210 | 0.2000 | 0.2000 | 0.1900 | 0.1528 | 0.0880 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.7-a

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1989 | SEP13 | SEP14 | SEP15 | SEP16 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 6.0 | 2.8 | 4.0 | 5.5 | 4.6 | 1.5 |
| VSS (mg/L) | 5.0 | 2.8 | 4.0 | 3.5 | 3.8 | 0.9 |
| Ammon (mg/L) | 4.90 | 4.98 | 4.90 | 4.90 | 4.92 | 0.04 |
| Nitrate (mg/L) | 0.03 * | 0.03 * | 0.03 * | 0.03 * | 0.03 | 0.00 |
| Nitrite (mg/L) | 0.005 | 0.004 | 0.005 | 0.005 | 0.005 | 0.001 |
| BOD (mg/L) | 2.6 | 3.6 | 1.0 | 3.0 | 2.6 | 1.1 |
| DOC (mg/L) | 9.0 | 8.5 | 8.5 | 9.0 | 8.8 | 0.3 |
| Sulphide (mg/L) | 0.025 * | 0.025 * | 0.025 * | 0.025 * | 0.025 | 0.000 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0370 | 0.0073 | 0.0220 | 0.0220 | 0.0221 | 0.0121 |
| Ni (mg/L) | 0.0110 | 0.0140 | 0.0120 | 0.0110 | 0.0120 | 0.0014 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0071 |
| Zn (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0400 | 0.0150 | 0.0168 |
| Fe (mg/L) | 0.1500 | 0.0938 | 0.1000 | 0.1700 | 0.1285 | 0.0374 |
| Mn (mg/L) | 0.0800 | 0.0750 | 0.0800 | 0.0800 | 0.0788 | 0.0025 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0900 | 0.0300 | 0.0400 | 0.0400 | 0.0500 | 0.0271 |
| As (mg/L) | 0.0050 * | 0.0075 | 0.0050 * | 0.0050 * | 0.0056 | 0.0013 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 71.00 | 69.00 | 63.00 | 63.00 | 66.50 | 4.12 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0088 | 0.0075 |
| Mg (mg/L) | 14.00 | 15.00 | 15.00 | 15.00 | 14.75 | 0.50 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.5000 | 0.4800 | 0.4700 | 0.4300 | 0.4700 | 0.0294 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.7-b

## EFFLUENT CHEMICAL QUALITY - PERTH

COMPOSITES - FILTERED

| DATE: 1989 | SEP13 | SEP14 | SEP15 | SEP16 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0190 | 0.0120 | 0.0200 | 0.0470 | 0.0245 | 0.0154 |
| Ni (mg/L) | 0.0160 | 0.0095 | 0.0100 | 0.0110 | 0.0116 | 0.0030 |
| Pb (mg/L) | 0.0100 | 0.0075 | 0.0250 * | 0.0100 | 0.0131 | 0.0080 |
| Zn (mg/L) | 0.0050 * | 0.0075 | 0.0100 * | 0.0200 | 0.0106 | 0.0066 |
| Fe (mg/L) | 0.0800 | 0.0770 | 0.2600 | 0.0750 | 0.1230 | 0.0914 |
| Mn (mg/L) | 0.0800 | 0.0800 | 0.0790 | 0.0800 | 0.0798 | 0.0005 |
| Ag (mg/L) | 0.0500 * | 0.0050 * | 0.0100 * | 0.0500 * | 0.0288 | 0.0246 |
| Al (mg/L) | 0.1000 | 0.0025 | 0.0250 * | 0.0400 | 0.0419 | 0.0417 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0100 * | 0.0050 * | 0.0063 | 0.0025 |
| Ca (mg/L) | 61.00 | 68.00 | 61.79 | 67.00 | 64.45 | 3.56 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0050 * | 0.0080 | 0.0045 | 0.0026 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0050 * | 0.0025 * | 0.0031 | 0.0013 |
| Hg (ug/L) | 0.0050 * | 0.0300 | 0.0050 * | 0.1500 | 0.0475 | 0.0693 |
| Mg (mg/L) | 14.00 | 13.50 | 14.00 | 15.00 | 14.13 | 0.63 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0100 * | 0.0025 * | 0.0044 | 0.0038 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.5100 | 0.4600 | 0.4800 | 0.4400 | 0.4725 | 0.0299 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0050 * | 0.0100 * | 0.0088 | 0.0025 |

* reported concentration = MDL/2
NA - not analysed

TABLE F.1.7-c

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1989 | SEP13 | SEP14 | SEP15 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| **GRAB - NON-FILTERED** | | | | | |
| SS (mg/L) | 5.0 | 3.0 | 2.5 | 3.5 | 1.3 |
| VSS (mg/L) | 3.0 | 3.0 | 1.3 | 2.4 | 1.0 |
| Ammon (mg/L) | 4.75 | 4.95 | 4.85 | 4.85 | 0.10 |
| Nitrate (mg/L) | 0.03 * | 0.03 * | 0.03 * | 0.03 | 0.00 |
| Nitrite (mg/L) | 0.005 | 0.005 | 0.003 * | 0.004 | 0.001 |
| BOD (mg/L) | 4.8 | 3.6 | 1.7 | 3.4 | 1.6 |
| DOC (mg/L) | 10.0 | 9.0 | 9.0 | 9.3 | 0.6 |
| Sulphide (mg/L) | 0.025 * | 0.025 * | 0.025 * | 0.025 | 0.000 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0275 | 0.0110 | 0.0137 | 0.0127 |
| Ni (mg/L) | 0.0140 | 0.0110 | 0.0110 | 0.0120 | 0.0017 |
| Pb (mg/L) | 0.0200 | 0.0125 * | 0.0200 | 0.0175 | 0.0043 |
| Zn (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Fe (mg/L) | 0.1100 | 0.1050 | 0.0860 | 0.1003 | 0.0127 |
| Mn (mg/L) | 0.0900 | 0.0800 | 0.0800 | 0.0833 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0700 | 0.0400 | 0.0100 * | 0.0400 | 0.0321 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 68.00 | 70.00 | 57.00 | 65.0000 | 7.00 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Mg (mg/L) | 15.00 | 15.00 | 14.00 | 14.6667 | 0.58 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0060 | 0.0037 | 0.0020 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.5800 | 0.4600 | 0.4100 | 0.4833 | 0.0862 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.7-d

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1989 | SEP13 | SEP14 | SEP15 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | |
| SS (mg/L) | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | | |
| Cu (mg/L) | 0.0025 * | 0.0078 | 0.0200 | 0.0101 | 0.0090 |
| Ni (mg/L) | 0.0130 | 0.0050 * | 0.0300 | 0.0160 | 0.0128 |
| Pb (mg/L) | 0.0050 * | 0.0075 | 0.0250 * | 0.0125 | 0.0109 |
| Zn (mg/L) | 0.0050 * | 0.0075 | 0.0100 * | 0.0075 | 0.0025 |
| Fe (mg/L) | 0.0890 | 0.0860 | 0.0500 * | 0.0750 | 0.0217 |
| Mn (mg/L) | 0.0800 | 0.0800 | 0.0810 | 0.0803 | 0.0006 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0100 * | 0.0367 | 0.0231 |
| Al (mg/L) | 0.1000 | 0.0025 | 0.0250 * | 0.0425 | 0.0511 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0100 * | 0.0067 | 0.0029 |
| Ca (mg/L) | 62.00 | 68.00 | 63.77 | 64.59 | 3.08 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0050 * | 0.0033 | 0.0014 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0050 * | 0.0033 | 0.0014 |
| Hg (ug/L) | 0.0600 | 0.0300 | 0.0050 * | 0.0317 | 0.0275 |
| Mg (mg/L) | 15.00 | 14.50 | 15.00 | 14.83 | 0.29 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0100 * | 0.0050 | 0.0043 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.5400 | 0.4800 | 0.5000 | 0.5067 | 0.0306 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0050 * | 0.0083 | 0.0029 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.8-a

## EFFLUENT CHEMICAL QUALITY - STRATFORD

| DATE: 1989 | JUL12 | JUL13 | JUL14 | JUL15 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 2.5 | 4.5 | 3.5 | 5.0 | 3.9 | 1.1 |
| VSS (mg/L) | 2.1 | 4.0 | 1.9 | 3.0 | 2.8 | 1.0 |
| Ammon (mg/L) | 14.20 | 14.95 | 14.80 | 17.40 | 15.34 | 1.41 |
| Nitrate (mg/L) | 1.70 | 2.15 | 2.55 | 2.20 | 2.15 | 0.35 |
| Nitrite (mg/L) | 1.500 | 2.195 | 2.090 | 1.800 | 1.896 | 0.313 |
| BOD (mg/L) | 18.9 | 15.2 | 20.6 | 28.9 | 20.9 | 5.8 |
| DOC (mg/L) | 6.5 | 6.0 | 6.0 | 7.0 | 6.4 | 0.5 |
| TRC (mg/L) | 0.01 | 0.005 * | 0.005 * | 0.005 * | 0.006 | 0.002 |
| Cu (mg/L) | 0.0025 * | 0.0043 | 0.0025 * | 0.0025 * | 0.0030 | 0.0009 |
| Ni (mg/L) | 0.0130 | 0.0150 | 0.0230 | 0.0480 | 0.0248 | 0.0161 |
| Pb (mg/L) | 0.0050 * | 0.0125 | 0.0200 | 0.0100 | 0.0119 | 0.0062 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0400 | 0.0300 | 0.0325 | 0.0050 |
| Fe (mg/L) | 0.2300 | 0.0815 | 0.0980 | 0.3300 | 0.1849 | 0.1174 |
| Mn (mg/L) | 0.0800 | 0.0900 | 0.0900 | 0.1100 | 0.0925 | 0.0126 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0900 | 0.1000 | 0.1100 | 0.1300 | 0.1075 | 0.0171 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.25 | 0.21 | 0.22 | 0.37 | 0.26 | 0.07 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0050 * | 0.0200 | 0.0050 * | 0.0088 | 0.0075 |
| Mg (mg/L) | 25.00 | 26.50 | 25.00 | 25.00 | 25.38 | 0.75 |
| Mo (mg/L) | 0.0240 | 0.0290 | 0.0250 | 0.0280 | 0.0265 | 0.0024 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 6.10 | 7.05 | 8.00 | 8.00 | 7.29 | 0.91 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.8-b

## EFFLUENT CHEMICAL QUALITY - STRATFORD

| DATE: 1989 | JUL12 | JUL13 | JUL14 | JUL15 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0080 | 0.0038 | 0.0025 * | 0.0060 | 0.0051 | 0.0024 |
| Ni (mg/L) | 0.0140 | 0.0140 | 0.0250 | 0.0470 | 0.0250 | 0.0156 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0000 |
| Fe (mg/L) | 0.1600 | 0.0480 | 0.0470 | 0.1600 | 0.1038 | 0.0650 |
| Mn (mg/L) | 0.0800 | 0.0800 | 0.0900 | 0.1100 | 0.0900 | 0.0141 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1000 | 0.1200 | 0.1200 | 0.1200 | 0.1150 | 0.0100 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 0.21 | 0.21 | 0.22 | 0.32 | 0.24 | 0.05 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0050 | 0.0031 | 0.0013 |
| Cr (mg/L) | 0.0850 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0231 | 0.0413 |
| Hg (ug/L) | 0.0400 | 0.0300 | 0.1500 | 0.0500 | 0.0675 | 0.0556 |
| Mg (mg/L) | 26.00 | 26.00 | 26.00 | 25.00 | 25.75 | 0.50 |
| Mo (mg/L) | 0.0270 | 0.0300 | 0.0260 | 0.0270 | 0.0275 | 0.0017 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 6.0000 | 8.1000 | 8.1000 | 8.0000 | 7.5500 | 1.0344 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.9-a

## EFFLUENT CHEMICAL QUALITY - WALKERTON

| DATE: 1989 | JUN21 | JUN22 | JUN23 | JUN24 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 4.2 | 9.0 | 11.3 | 25.0 | 12.4 | 8.9 |
| VSS (mg/L) | 3.1 | 6.8 | 9.7 | 22.8 | 10.6 | 8.6 |
| Ammon (mg/L) | 0.05 | 0.10 | 0.10 | 0.10 | 0.09 | 0.03 |
| Nitrate (mg/L) | 15.20 | 15.00 | 15.50 | 15.70 | 15.35 | 0.31 |
| Nitrite (mg/L) | 0.045 | 0.045 | 0.090 | 0.125 | 0.0[illegible] | 0.039 |
| BOD (mg/L) | 3.8 | 4.7 | 3.7 | 4.3 | 4.1 | 0.5 |
| DOC (mg/L) | 5.0 | 4.0 | 4.0 | 4.0 | 4.3 | 0.5 |
| TRC (mg/L) | 0.12 | 0.02 | 0.02 | 0.01 | 0.04 | 0.05 |
| | | | | | | |
| Cu (mg/L) | 0.0270 | 0.0300 | 0.0310 | 0.0540 | 0.0355 | 0.0124 |
| Ni (mg/L) | 0.0760 | 0.0820 | 0.0810 | 0.0800 | 0.0798 | 0.0026 |
| Pb (mg/L) | 0.0050 * | 0.0175 | 0.0100 | 0.0050 * | 0.0094 | 0.0059 |
| Zn (mg/L) | 0.0600 | 0.0800 | 0.0800 | 0.0900 | 0.0775 | 0.0126 |
| Fe (mg/L) | 0.1700 | 0.3700 | 0.2800 | 0.2700 | 0.2725 | 0.0818 |
| Mn (mg/L) | 0.0200 | 0.0200 | 0.0200 | 0.0500 | 0.0275 | 0.0150 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0500 | 0.1500 | 0.0900 | 0.0800 | 0.0925 | 0.0419 |
| As (mg/L) | 0.0050 * | 0.0275 | 0.0300 | 0.0300 | 0.0231 | 0.0121 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 867.00 | 200.00 | 210.00 | 200.00 | 369.25 | 331.87 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0200 | 0.0175 | 0.0200 | 0.0200 | 0.0194 | 0.0013 |
| Mg (mg/L) | 21.20 | 23.00 | 24.00 | 24.00 | 23.05 | 1.32 |
| Mo (mg/L) | 0.0025 * | 0.0060 | 0.0050 | 0.0025 * | 0.0040 | 0.0018 |
| Se (mg/L) | 0.0050 * | 0.0175 | 0.0300 | 0.0700 | 0.0306 | 0.0282 |
| Sr (mg/L) | 5.3400 | 4.5000 | 4.5000 | 4.5000 | 4.7100 | 0.4200 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.9-b

## EFFLUENT CHEMICAL QUALITY - WALKERTON

| DATE: 1989 | JUN21 | JUN22 | JUN23 | JUN24 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0280 | 0.0280 | 0.0240 | 0.0460 | 0.0315 | 0.0098 |
| Ni (mg/L) | 0.0590 | 0.0810 | 0.0740 | 0.0840 | 0.0745 | 0.0112 |
| Pb (mg/L) | 0.0300 | 0.2100 | 0.0050 * | 0.0050 * | 0.0625 | 0.0990 |
| Zn (mg/L) | 0.1100 | 0.1000 | 0.0700 * | 0.0800 | 0.0900 | 0.0183 |
| Fe (mg/L) | 0.0970 | 0.4290 | 0.0100 * | 0.0100 * | 0.1365 | 0.1993 |
| Mn (mg/L) | 0.0300 | 0.0200 | 0.0200 | 0.0500 | 0.0300 | 0.0141 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1900 | 0.4250 | 0.0700 | 0.0800 | 0.1913 | 0.1650 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0300 | 0.0300 | 0.0175 | 0.0144 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 180.00 | 200.00 | 210.00 | 210.00 | 200.00 | 14.14 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0043 | 0.0025 * | 0.0025 * | 0.0030 | 0.0009 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0200 | 0.0125 * | 0.0200 | 0.0700 | 0.0306 | 0.0265 |
| Mg (mg/L) | 22.00 | 23.00 | 24.00 | 24.00 | 23.25 | 0.96 |
| Mo (mg/L) | 0.0025 * | 0.0070 | 0.0025 * | 0.0025 * | 0.0036 | 0.0023 |
| Se (mg/L) | 0.0200 | 0.0050 * | 0.0300 | 0.0700 | 0.0313 | 0.0278 |
| Sr (mg/L) | 4.5000 | 4.5000 | 4.5000 | 4.5000 | 4.5000 | 0.0000 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.10-a

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1989 | SEP6 | SEP7 | SEP8 | SEP9 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 5.0 | 2.6 | 3.0 | 5.0 | 3.9 | 1.3 |
| VSS (mg/L) | 5.0 | 2.6 | 3.0 | 5.0 | 3.9 | 1.3 |
| Ammon (mg/L) | 7.65 | 6.95 | 4.25 | 6.90 | 6.44 | 1.50 |
| Nitrate (mg/L) | 8.50 | 7.48 | 5.80 | 6.35 | 7.03 | 1.20 |
| Nitrite (mg/L) | 1.680 | 1.045 | 0.785 | 0.890 | 1.100 | 0.401 |
| BOD (mg/L) | 2.4 | 7.5 | 14.6 | 18.8 | 10.8 | 7.3 |
| DOC (mg/L) | 14.5 | 15.0 | 16.5 | 13.5 | 14.9 | 1.2 |
| TRC (mg/L) | 0.14 | 0.10 | 0.08 | 0.005 * | 0.081 | 0.057 |
| Cu (mg/L) | 0.0440 | 0.0420 | 0.0180 | 0.0460 | 0.0375 | 0.0131 |
| Ni (mg/L) | 0.0390 | 0.0350 | 0.0920 | 0.0380 | 0.0510 | 0.0274 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0100 | 0.0200 | 0.0138 | 0.0075 |
| Zn (mg/L) | 0.0600 | 0.0600 | 0.0300 | 0.0400 | 0.0475 | 0.0150 |
| Fe (mg/L) | 0.3600 | 0.3200 | 0.2600 | 0.3700 | 0.3275 | 0.0499 |
| Mn (mg/L) | 0.1000 | 0.0900 | 0.0700 | 0.0700 | 0.0825 | 0.0150 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0100 * | 0.0300 | 0.0100 * | 0.0150 | 0.0100 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 81.00 | 69.50 | 70.00 | 68.00 | 72.13 | 5.98 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0080 | 0.0095 | 0.0060 | 0.0060 | 0.0074 | 0.0017 |
| Hg (ug/L) | 0.0200 | 0.0200 | 0.0050 * | 0.0050 * | 0.0125 | 0.0087 |
| Mg (mg/L) | 12.00 | 11.50 | 11.00 | 11.00 | 11.38 | 0.48 |
| Mo (mg/L) | 0.0260 | 0.0270 | 0.0025 * | 0.0230 | 0.0196 | 0.0115 |
| Se (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.2800 | 0.2300 | 0.2600 | 0.2200 | 0.2475 | 0.0275 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.1.10-b

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1989 | SEP6 | SEP7 | SEP8 | SEP9 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - FILTERED** | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0950 | 0.0380 | 0.0460 | 0.0480 | 0.0568 | 0.0259 |
| Ni (mg/L) | 0.0790 | 0.0340 | 0.0900 | 0.0280 | 0.0578 | 0.0313 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0088 | 0.0075 |
| Zn (mg/L) | 0.0700 | 0.0600 | 0.0500 | 0.0300 | 0.0525 | 0.0171 |
| Fe (mg/L) | 0.1800 | 0.0940 | 0.0870 | 0.0620 | 0.1058 | 0.0514 |
| Mn (mg/L) | 0.1000 | 0.0800 | 0.0700 | 0.0600 | 0.0775 | 0.0171 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0200 | 0.0100 * | 0.0100 * | 0.0300 | 0.0175 | 0.0096 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 73.00 | 62.00 | 69.00 | 58.00 | 65.50 | 6.76 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0070 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0036 | 0.0023 |
| Cr (mg/L) | 0.0160 | 0.0048 | 0.0025 * | 0.0025 * | 0.0065 | 0.0065 |
| Hg (ug/L) | 0.0400 | 0.0500 | 0.0400 | 0.0700 | 0.0500 | 0.0141 |
| Mg (mg/L) | 11.00 | 10.50 | 12.00 | 10.00 | 10.88 | 0.85 |
| Mo (mg/L) | 0.0290 | 0.0250 | 0.0025 * | 0.0230 | 0.0199 | 0.0118 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2700 | 0.2200 | 0.2100 | 0.2100 | 0.2275 | 0.0287 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.1.10-c

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1989 | SEP6 | SEP7 | 1 PM<br>SEP8 | 7 PM<br>SEP8 | MIDNITE<br>SEP8 | 8 AM<br>SEP9 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|---|---|
| **GRAB - NON-FILTERED** | | | | | | | | |
| SS (mg/L) | 5.0 | 3.5 | 3.0 | 5.5 | 5.0 | 4.0 | 4.3 | 1.0 |
| VSS (mg/L) | 4.0 | 2.1 | 3.0 | 7.0 | 2.5 | 4.0 | 3.8 | 1.8 |
| Ammon (mg/L) | 5.00 | 0.80 | 5.65 | 18.40 | 6.50 | 0.05 | 6.07 | 6.60 |
| Nitrate (mg/L) | 8.00 | 6.85 | 5.05 | 6.35 | 1.90 | 7.25 | 5.90 | 2.19 |
| Nitrite (mg/L) | 1.300 | 0.655 | 0.715 | 1.020 | 0.690 | 0.010 | 0.732 | 0.432 |
| BOD (mg/L) | 13.7 | 5.3 | 11.2 | 5.6 | 22.4 | 1.0 | 9.9 | 7.6 |
| DOC (mg/L) | 18.5 | 13.5 | 21.0 | 19.0 | 10.0 | 6.0 | 14.7 | 5.9 |
| TRC (mg/L) | 0.02 | 0.15 | 0.23 | 0.07 | 0.02 | 0.22 | 0.12 | 0.10 |
| Cu (mg/L) | 0.0860 | 0.0430 | 0.0440 | 0.0620 | 0.0720 | 0.0770 | 0.0640 | 0.0177 |
| Ni (mg/L) | 0.0300 | 0.6300 | 0.1000 | 0.0800 | 0.0430 | 0.0230 | 0.1510 | 0.2365 |
| Pb (mg/L) | 0.0300 | 0.0050 * | 0.0050 * | 0.0200 | 0.0050 * | 0.0200 | 0.0142 | 0.0107 |
| Zn (mg/L) | 0.0700 | 0.0500 | 0.0300 | 0.0400 | 0.0500 | 0.0300 | 0.0450 | 0.0152 |
| Fe (mg/L) | 0.3000 | 0.2000 | 0.3300 | 0.3700 | 0.4400 | 0.2200 | 0.3100 | 0.0908 |
| Mn (mg/L) | 0.0900 | 0.0900 | 0.0800 | 0.0800 | 0.0700 | 0.0600 | 0.0783 | 0.0117 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0300 | 0.0100 * | 0.0300 | 0.0300 | 0.0800 | 0.0317 | 0.0256 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0058 | 0.0020 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 81.00 | 69.50 | 69.00 | 76.00 | 43.00 | 81.00 | 69.92 | 14.20 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0100 | 0.0080 | 0.0080 | 0.0070 | 0.0025 * | 0.0060 | 0.0069 | 0.0025 |
| Hg (ug/L) | 0.1100 | 0.0175 | 0.0030 * | 0.0200 | 0.0200 | 0.0050 * | 0.0293 | 0.0403 |
| Mg (mg/L) | 13.0000 | 12.00 | 12.00 | 11.00 | 7.70 | 13.00 | 11.45 | 1.98 |
| Mo (mg/L) | 0.0290 | 0.0240 | 0.0060 | 0.0230 | 0.0230 | 0.0250 | 0.0217 | 0.0080 |
| Se (mg/L) | 0.0050 * | 0.0075 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0054 | 0.0010 |
| Sr (mg/L) | 0.2900 | 0.2400 | 0.2300 | 0.2200 | 0.1800 | 0.2900 | 0.2417 | 0.0426 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.1-a

## EFFLUENT CHEMICAL QUALITY - BRACEBRIDGE

| DATE: 1989 | DEC12 | DEC13 | DEC14 | DEC15 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 6.3 | 3.4 | 3.8 | 6.4 | 5.0 | 1.6 |
| VSS (mg/L) | 4.5 | 3.1 | 3.3 | 4.2 | 3.8 | 0.7 |
| Ammon (mg/L) | 0.05 | 0.10 | 0.10 | 0.20 | 0.11 | 0.06 |
| Nitrate (mg/L) | 17.90 | 18.60 | 18.90 | 19.70 | 18.78 | 0.75 |
| Nitrite (mg/L) | 0.175 | 0.795 | 1.150 | 1.790 | 0.978 | 0.675 |
| BOD (mg/L) | 3.2 | 4.3 | 4.9 | 10.0 | 5.6 | 3.0 |
| DOC (mg/L) | 6.5 | 6.5 | 6.0 | 8.0 | 6.8 | 0.9 |
| TRC (mg/L) | 0.02 | 0.005 * | 0.005 * | 0.005 * | 0.009 | 0.007 |
| Cu (mg/L) | 0.0090 | 0.0140 | 0.0160 | 0.0170 | 0.0140 | 0.0036 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0000 |
| Fe (mg/L) | 0.1300 | 0.1050 | 0.1600 | 0.2200 | 0.1538 | 0.0496 |
| Mn (mg/L) | 0.1000 | 0.1100 | 0.1200 | 0.1300 | 0.1150 | 0.0129 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.6500 | 0.4200 | 0.5400 | 0.7700 | 0.5950 | 0.1498 |
| As (mg/L) | 0.0200 | 0.0200 | 0.0200 | 0.0100 | 0.0175 | 0.0050 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 31.00 | 32.50 | 35.00 | 36.00 | 33.63 | 2.29 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0050 * | 0.0031 | 0.0013 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0300 | 0.0200 | 0.0200 | 0.0300 | 0.0250 | 0.0058 |
| Mg (mg/L) | 5.10 | 4.90 | 4.90 | 4.80 | 4.93 | 0.13 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0200 | 0.0050 * | 0.0088 | 0.0075 |
| Sr (mg/L) | 0.1400 | 0.1400 | 0.1400 | 0.1300 | 0.1375 | 0.0050 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.1-b

## EFFLUENT CHEMICAL QUALITY - BRACEBRIDGE

| DATE: 1989 | DEC12 | DEC13 | DEC14 | DEC15 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0070 | 0.0130 | 0.0180 | 0.0140 | 0.0130 | 0.0045 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0400 | 0.0500 | 0.0500 | 0.0500 | 0.0475 | 0.0050 |
| Fe (mg/L) | 0.0100 * | 0.0360 | 0.0770 | 0.0670 | 0.0475 | 0.0305 |
| Mn (mg/L) | 0.0900 | 0.1000 | 0.1100 | 0.1200 | 0.1050 | 0.0129 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1100 | 0.1200 | 0.1300 | 0.1300 | 0.1225 | 0.0096 |
| As (mg/L) | 0.0100 | 0.0200 | 0.0200 | 0.0050 | 0.0138 | 0.0075 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 30.00 | 32.00 | 35.00 | 36.00 | 33.25 | 2.75 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0900 | 0.0400 | 0.0300 | 0.0500 | 0.0525 | 0.0263 |
| Mg (mg/L) | 4.80 | 4.90 | 4.90 | 4.80 | 4.85 | 0.06 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0050 * | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.1300 | 0.1300 | 0.1300 | 0.1300 | 0.1300 | 0.0000 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.2-a

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | MAR22 | MAR23 | MAR24 | MAR25 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 23.0 | 48.0 | 17.0 | 24.0 | 28.0 | 13.7 |
| VSS (mg/L) | 18.0 | 34.0 | 16.0 | 22.0 | 22.5 | 8.1 |
| Ammon (mg/L) | 11.90 | 15.40 | 17.90 | 18.40 | 15.90 | 2.97 |
| Nitrate (mg/L) | 6.85 | 4.65 | 4.60 | 2.85 | 4.74 | 1.64 |
| Nitrite (mg/L) | 7.250 | 4.310 | 4.630 | 3.000 | 4.798 | 1.781 |
| BOD (mg/L) | 3.5 | 36.4 | 41.6 | 41.6 | 30.8 | 18.3 |
| DOC (mg/L) | 15.4 | 14.5 | 14.0 | 15.0 | 14.7 | 0.6 |
| TRC (mg/L) | 0.12 | 0.03 | 0.03 | 0.005 * | 0.046 | 0.051 |
| Cu (mg/L) | 0.0350 | 0.0320 | 0.0270 | 0.0460 | 0.0350 | 0.0080 |
| Ni (mg/L) | 0.0250 | 0.0260 | 0.0320 | 0.0220 | 0.0263 | 0.0042 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0200 | 0.0200 | 0.0163 | 0.0075 |
| Zn (mg/L) | 0.0700 | 0.0700 | 0.0700 | 0.0900 | 0.0750 | 0.0100 |
| Fe (mg/L) | 1.8000 | 1.6000 | 1.4000 | 2.2000 | 1.7500 | 0.3416 |
| Mn (mg/L) | 0.3800 | 0.3600 | 0.3800 | 0.3900 | 0.3775 | 0.0126 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1900 | 0.1200 | 0.1100 | 0.2200 | 0.1600 | 0.0535 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 166.00 | 166.00 | 160.00 | 160.00 | 163.00 | 3.46 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0090 | 0.0610 | 0.0160 | 0.0480 | 0.0335 | 0.0250 |
| Hg (ug/L) | 0.0500 | 0.0500 | 0.0200 | 0.0400 | 0.0400 | 0.0141 |
| Mg (mg/L) | 9.50 | 9.72 | 9.80 | 9.90 | 9.73 | 0.17 |
| Mo (mg/L) | 0.0060 | 0.0080 | 0.0090 | 0.0070 | 0.0075 | 0.0013 |
| Se (mg/L) | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 | 0.0063 | 0.0025 |
| Sr (mg/L) | 0.1900 | 0.1900 | 0.1900 | 0.1900 | 0.1900 | 0.0000 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.2-b

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | MAR22 | MAR23 | MAR24 | MAR25 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0430 | 0.0300 | 0.0340 | 0.0330 | 0.0350 | 0.0056 |
| Ni (mg/L) | 0.0230 | 0.0240 | 0.0320 | 0.0240 | 0.0258 | 0.0042 |
| Pb (mg/L) | 0.0200 | 0.0100 | 0.0050 * | 0.0050 * | 0.0100 | 0.0071 |
| Zn (mg/L) | 0.1000 | 0.1000 | 0.1100 | 0.1100 | 0.1050 | 0.0058 |
| Fe (mg/L) | 0.0730 | 0.0930 | 0.1200 | 0.0780 | 0.0910 | 0.0211 |
| Mn (mg/L) | 0.3400 | 0.3400 | 0.3700 | 0.3500 | 0.3500 | 0.0141 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0100 * | 0.1600 | 0.0300 | 0.0525 | 0.0723 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 159.00 | 162.00 | 160.00 | 144.00 | 156.25 | 8.26 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.1200 | 0.0070 | 0.0150 | 0.0080 | 0.0375 | 0.0551 |
| Hg (ug/L) | 0.0500 | 0.0400 | 0.0200 | 0.0200 | 0.0325 | 0.0150 |
| Mg (mg/L) | 9.20 | 9.50 | 9.80 | 9.40 | 9.48 | 0.25 |
| Mo (mg/L) | 0.0025 * | 0.0060 | 0.0080 | 0.0050 | 0.0054 | 0.0023 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.1800 | 0.1900 | 0.1900 | 0.1800 | 0.1850 | 0.0058 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.2-c

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | MAR22 | MAR23 | MAR24 | MAR25 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| GRAB - NON-FILTERED | | | | | | |
| SS (mg/L) | 8.0 | 27.5 | 12.0 | 12.0 | 14.9 | 8.6 |
| VSS (mg/L) | 2.0 | 20.0 | 8.0 | 10.0 | 10.0 | 7.5 |
| Ammon (mg/L) | 10.70 | 19.30 | 16.60 | 17.20 | 15.95 | 3.69 |
| Nitrate (mg/L) | 8.15 | 4.70 | 4.45 | 2.30 | 4.90 | 2.42 |
| Nitrite (mg/L) | 8.000 | 4.380 | 4.130 | 2.330 | 4.710 | 2.376 |
| BOD (mg/L) | 1.0 | 56.4 | 22.0 | 16.4 | 24.0 | 23.4 |
| DOC (mg/L) | 15.2 | 14.0 | 14.5 | 15.0 | 14.7 | 0.5 |
| TRC (mg/L) | 0.26 | 0.005 * | 0.18 | 0.24 | 0.171 | 0.12 |
| Cu (mg/L) | 0.0270 | 0.0430 | 0.0210 | 0.0180 | 0.0273 | 0.0111 |
| Ni (mg/L) | 0.0250 | 0.0260 | 0.0290 | 0.0180 | 0.0245 | 0.0047 |
| Pb (mg/L) | 0.0300 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0113 | 0.0125 |
| Zn (mg/L) | 0.0800 | 0.0600 | 0.0500 | 0.0400 | 0.0575 | 0.0171 |
| Fe (mg/L) | 0.0770 | 2.1000 | 0.7200 | 1.1000 | 0.9993 | 0.8466 |
| Mn (mg/L) | 0.3500 | 0.3600 | 0.3900 | 0.3600 | 0.3650 | 0.0173 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.5000 | 0.2000 | 0.0800 | 0.1300 | 0.2275 | 0.1882 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 167.00 | 162.00 | 161.00 | 163.00 | 163.25 | 2.63 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0120 | 0.0060 | 0.0160 | 0.0091 | 0.0060 |
| Hg (ug/L) | 0.0200 | 0.0400 | 0.0200 | 0.0050 * | 0.0213 | 0.0144 |
| Mg (mg/L) | 9.30 | 9.70 | 9.60 | 9.70 | 9.58 | 0.19 |
| Mo (mg/L) | 0.0025 * | 0.0080 | 0.0050 | 0.0025 * | 0.0045 | 0.0026 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.1900 | 0.2000 | 0.2000 | 0.2000 | 0.1975 | 0.0050 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.2-d

## EFFLUENT CHEMICAL QUALITY - HIGHLAND CREEK

| DATE: 1989 | MAR22 | MAR23 | MAR24 | MAR25 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0210 | 0.0390 | 0.0220 | 0.0210 | 0.0258 | 0.0088 |
| Ni (mg/L) | 0.0260 | 0.0280 | 0.0280 | 0.0170 | 0.0248 | 0.0053 |
| Pb (mg/L) | 0.0200 | 0.0100 | 0.0200 | 0.0200 | 0.0175 | 0.0050 |
| Zn (mg/L) | 0.0500 | 0.0900 | 0.0700 | 0.0800 | 0.0725 | 0.0171 |
| Fe (mg/L) | 0.7800 | 0.0450 | 0.0600 | 0.1300 | 0.2538 | 0.3528 |
| Mn (mg/L) | 0.3700 | 0.3500 | 0.3600 | 0.1750 | 0.3138 | 0.0929 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0800 | 0.0400 | 0.0500 | 0.0300 | 0.0500 | 0.0216 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 168.00 | 161.00 | 155.00 | 160.00 | 161.00 | 5.35 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0050 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0031 | 0.0012 |
| Cr (mg/L) | 0.0080 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0039 | 0.0028 |
| Hg (ug/L) | 0.0300 | 0.0200 | 0.0200 | 0.0200 | 0.0225 | 0.0050 |
| Mg (mg/L) | 9.60 | 9.90 | 9.30 | 9.70 | 9.63 | 0.25 |
| Mo (mg/L) | 0.0050 | 0.0080 | 0.0060 | 0.0025 * | 0.0054 | 0.0023 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2000 | 0.1900 | 0.1900 | 0.1900 | 0.1925 | 0.0050 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.3-a

## EFFLUENT CHEMICAL QUALITY - HUNTSVILLE

COMPOSITES - NON-FILTERED

| DATE: 1989 | DEC6 | DEC7 | DEC8 | DEC9 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| SS (mg/L) | 7.2 | 5.5 | 5.6 | 8.2 | 6.6 | 1.3 |
| VSS (mg/L) | 5.8 | 4.7 | 4.0 | 7.4 | 5.5 | 1.5 |
| Ammon (mg/L) | 12.10 | 11.80 | 12.70 | 12.90 | 12.38 | 0.51 |
| Nitrate (mg/L) | 2.30 | 4.20 | 4.45 | 4.25 | 3.80 | 1.01 |
| Nitrite (mg/L) | 0.065 | 0.045 | 0.055 | 0.060 | 0.056 | 0.009 |
| BOD (mg/L) | 0.5 | 0.1 | 1.6 | 1.3 | 0.9 | 0.7 |
| DOC (mg/L) | 8.5 | 7.0 | 9.0 | 8.5 | 8.3 | 0.9 |
| TRC (mg/L) | 1.05 | 1.09 | 0.98 | 0.67 | 0.95 | 0.19 |
| Cu (mg/L) | 0.0090 | 0.0050 * | 0.0025 * | 0.0025 * | 0.0048 | 0.0031 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0000 |
| Fe (mg/L) | 0.3000 | 0.1800 | 0.1700 | 0.6650 | 0.3288 | 0.2318 |
| Mn (mg/L) | 0.2000 | 0.2000 | 0.1900 | 0.1800 | 0.1925 | 0.0096 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.8700 | 0.7900 | 0.9400 | 0.9000 | 0.8750 | 0.0635 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 35.90 | 35.30 | 32.09 | 30.00 | 33.32 | 2.78 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.0200 | 0.0500 | 0.5800 | 0.1725 | 0.2720 |
| Mg (mg/L) | 6.20 | 6.20 | 6.10 | 5.80 | 6.08 | 0.19 |
| Mo (mg/L) | 0.0100 | 0.0100 | 0.0060 | 0.0043 * | 0.0076 | 0.0029 |
| Se (mg/L) | 0.0100 | 0.0500 * | 0.0050 * | 0.0050 * | 0.0175 | 0.0218 |
| Sr (mg/L) | 0.1600 | 0.1500 | 0.1600 | 0.1500 | 0.1550 | 0.0058 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.3-b

## EFFLUENT CHEMICAL QUALITY - HUNTSVILLE

| DATE: 1989 | DEC6 | DEC7 | DEC8 | DEC9 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - FILTERED** | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0080 | 0.0090 | 0.0025 * | 0.0025 * | 0.0055 | 0.0035 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0300 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0113 | 0.0125 |
| Zn (mg/L) | 0.0500 | 0.0400 | 0.0300 | 0.0300 | 0.0375 | 0.0096 |
| Fe (mg/L) | 0.1500 | 0.0940 | 0.0920 | 0.1030 | 0.1098 | 0.0273 |
| Mn (mg/L) | 0.2000 | 0.2000 | 0.1700 | 0.1700 | 0.1850 | 0.0173 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.2100 | 0.1700 | 0.2200 | 0.2300 | 0.2075 | 0.0263 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 36.50 | 36.00 | 29.88 | 29.00 | 32.85 | 3.95 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0700 | 0.0500 | 0.0500 | 0.4200 | 0.1475 | 0.1819 |
| Mg (mg/L) | 6.30 | 6.30 | 5.70 | 5.65 | 5.99 | 0.36 |
| Mo (mg/L) | 0.0080 | 0.0090 | 0.0025 * | 0.0025 * | 0.0055 | 0.0035 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.1600 | 0.1600 | 0.1500 | 0.1500 | 0.1550 | 0.0058 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.4-a

## EFFLUENT CHEMICAL QUALITY - LINDSAY

COMPOSITES - NON-FILTERED

| DATE: 1989 | MAR29 | MAR30 | MAR31 | APR1 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| SS (mg/L) | 26.5 | 20.6 | 15.0 | 19.5 | 20.4 | 4.7 |
| VSS (mg/L) | 19.0 | 14.3 | 12.0 | 15.5 | 15.2 | 2.9 |
| Ammon (mg/L) | 15.20 | 14.40 | 14.20 | 14.00 | 14.45 | 0.53 |
| Nitrate (mg/L) | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 |
| Nitrite (mg/L) | 0.015 | 0.005 | 0.005 | 0.010 | 0.009 | 0.005 |
| BOD (mg/L) | 17.5 | 18.5 | 14.6 | 13.7 | 16.1 | 2.3 |
| DOC (mg/L) | 14.0 | 14.5 | 14.5 | 13.5 | 14.1 | 0.5 |
| Sulphide (mg/L) | 0.005 * | 0.02 | 0.06 | 0.04 | 0.031 | 0.024 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0080 | 0.0110 | 0.0110 | 0.0080 | 0.0095 | 0.0017 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0200 | 0.0200 | 0.0100 | 0.0200 | 0.0175 | 0.0050 |
| Zn (mg/L) | 0.0500 | 0.0500 | 0.0400 | 0.0500 | 0.0475 | 0.0050 |
| Fe (mg/L) | 0.2900 | 0.2600 | 0.2100 | 0.2500 | 0.2525 | 0.0330 |
| Mn (mg/L) | 0.0600 | 0.0600 | 0.0500 | 0.0500 | 0.0550 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 1.1000 | 1.3000 | 1.2000 | 0.9900 | 1.1475 | 0.1330 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0100 * | 0.0100 * | 0.0075 | 0.0029 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 347.00 | 291.00 | 320.00 | 273.00 | 307.75 | 32.55 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0130 | 0.0080 | 0.0070 | 0.0480 | 0.0190 | 0.0195 |
| Hg (ug/L) | 0.0700 | 0.0400 | 0.0200 | 0.0200 | 0.0375 | 0.0236 |
| Mg (mg/L) | 12.00 | 11.00 | 10.00 | 10.00 | 10.75 | 0.96 |
| Mo (mg/L) | 0.0480 | 0.0500 | 0.0450 | 0.0450 | 0.0470 | 0.0024 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0300 | 0.0400 | 0.0200 | 0.0178 |
| Sr (mg/L) | 0.2300 | 0.2400 | 0.2200 | 0.2100 | 0.2250 | 0.0129 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.4-b

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | MAR29 | MAR30 | MAR31 | APR1 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| | NA | NA | NA | NA | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0100 | 0.0110 | 0.0080 | 0.0100 | 0.0098 | 0.0013 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0200 | 0.0050 * | 0.0125 | 0.0087 |
| Zn (mg/L) | 0.0500 | 0.0500 | 0.0400 | 0.0400 | 0.0450 | 0.0058 |
| Fe (mg/L) | 0.1000 | 0.1200 | 0.0790 | 0.4900 | 0.1973 | 0.1959 |
| Mn (mg/L) | 0.0600 | 0.0500 | 0.0500 | 0.0500 | 0.0525 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1500 | 0.1200 | 0.1400 | 0.1000 | 0.1275 | 0.0222 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0075 | 0.0029 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 341.00 | 285.00 | 285.00 | 268.00 | 294.75 | 31.86 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0060 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0034 | 0.0018 |
| Hg (ug/L) | 0.0600 | 0.0150 | 0.0200 | 0.0200 | 0.0288 | 0.0210 |
| Mg (mg/L) | 11.00 | 11.00 | 10.00 | 10.00 | 10.50 | 0.58 |
| Mo (mg/L) | 0.0380 | 0.0360 | 0.0360 | 0.0330 | 0.0358 | 0.0021 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0200 | 0.0200 | 0.0125 | 0.0087 |
| Sr (mg/L) | 0.2300 | 0.2300 | 0.2200 | 0.2100 | 0.2225 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.4-c

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | MAR29 | MAR30 | MAR31 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| GRAB - NON-FILTERED | | | | | |
| SS (mg/L) | 25.0 | 19.5 | 19.0 | 21.2 | 3.3 |
| VSS (mg/L) | 16.5 | 8.0 | 15.0 | 13.2 | 4.5 |
| Ammon (mg/L) | 15.10 | 14.50 | 14.70 | 14.77 | 0.31 |
| Nitrate (mg/L) | 0.03 * | 0.03 * | 0.03 * | 0.03 | 0.00 |
| Nitrite (mg/L) | 0.005 | 0.005 | 0.005 | 0.005 | 0.000 |
| BOD (mg/L) | 18.5 | 18.6 | 19.8 | 19.0 | 0.7 |
| DOC (mg/L) | 14.5 | 14.0 | 16.0 | 14.8 | 1.0 |
| Sulphide (mg/L) | 0.02 | 0.02 | 0.08 | 0.04 | 0.03 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| | | | | | |
| Cu (mg/L) | 0.0110 | 0.0070 | 0.0080 | 0.0087 | 0.0021 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0200 | 0.0300 | 0.0050 * | 0.0183 | 0.0126 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0000 |
| Fe (mg/L) | 1.1000 | 0.2300 | 0.2000 | 0.5100 | 0.5112 |
| Mn (mg/L) | 0.0600 | 0.0500 | 0.0500 | 0.0533 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 1.2000 | 1.3000 | 1.1000 | 1.2000 | 0.1000 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0200 * | 0.0100 | 0.0087 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 335.00 | 293.00 | 298.00 | 308.67 | 22.94 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0060 | 0.0060 | 0.0060 | 0.0060 | 0.0000 |
| Hg (ug/L) | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0000 |
| Mg (mg/L) | 11.00 | 11.00 | 10.00 | 10.67 | 0.58 |
| Mo (mg/L) | 0.0510 | 0.0460 | 0.0440 | 0.0470 | 0.0036 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0300 | 0.0133 | 0.0144 |
| Sr (mg/L) | 0.2400 | 0.2300 | 0.2200 | 0.2300 | 0.0100 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.4-d

## EFFLUENT CHEMICAL QUALITY - LINDSAY

| DATE: 1989 | MAR29 | MAR30 | MAR31 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | |
| SS (mg/L) | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | | |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0050 | 0.0033 | 0.0013 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0300 | 0.0300 | 0.0000 |
| Fe (mg/L) | 0.1000 | 0.1000 | 0.1300 | 0.1100 | 0.0173 |
| Mn (mg/L) | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.0000 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0100 * | 0.0067 | 0.0026 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 296.00 | 283.00 | 281.00 | 286.67 | 8.14 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0300 | 0.0050 * | 0.0200 | 0.0183 | 0.0119 |
| Mg (mg/L) | 11.00 | 10.00 | 10.00 | 10.33 | 0.58 |
| Mo (mg/L) | 0.0360 | 0.0340 | 0.0330 | 0.0343 | 0.0015 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0300 | 0.0133 | 0.0132 |
| Sr (mg/L) | 0.2200 | 0.2200 | 0.2200 * | 0.2200 | 0.0000 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.5-a

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| DATE: 1989 | JAN10 | JAN11 | JAN12 | JAN13 | AVG. | STD DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 5.7 | 6.5 | 4.6 | 5.3 | 5.5 | 0.8 |
| VSS (mg/L) | 3.9 | 4.2 | 3.9 | 4.7 | 4.2 | 0.4 |
| Ammon (mg/L) | 12.40 | 10.80 | 4.25 | 7.40 | 8.71 | 3.63 |
| Nitrate (mg/L) | 1.35 | 3.15 | 6.45 | 4.10 | 3.76 | 2.12 |
| Nitrite (mg/L) | 0.310 | 0.568 | 1.430 | 0.660 | 0.742 | 0.482 |
| BOD (mg/L) | 24.4 | 21.0 | 30.3 | 29.0 | 26.2 | 4.3 |
| DOC (mg/L) | 5.3 | 4.6 | 4.1 | 5.2 | 4.8 | 0.6 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0120 | 0.0025 * | 0.0090 | 0.0065 | 0.0048 |
| Ni (mg/L) | 0.1200 | 0.1200 | 0.2300 | 0.2100 | 0.1700 | 0.0583 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0088 | 0.0075 |
| Zn (mg/L) | 0.1000 | 0.0800 | 0.0700 | 0.0500 | 0.0750 | 0.0208 |
| Fe (mg/L) | 0.8200 | 0.5350 | 0.5300 | 0.5000 | 0.5963 | 0.1500 |
| Mn (mg/L) | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0425 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1700 | 0.1000 | 0.1200 | 0.0600 | 0.1125 | 0.0457 |
| As (mg/L) | 0.0100 | 0.0200 | 0.0050 * | 0.0050 * | 0.0100 | 0.0071 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 57.00 | 47.92 | 53.40 | 44.20 | 50.63 | 5.68 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0070 | 0.0025 * | 0.0140 | 0.0120 | 0.0089 | 0.0052 |
| Cr (mg/L) | 0.0060 | 0.0025 * | 0.0050 | 0.0025 * | 0.0040 | 0.0018 |
| Hg (ug/L) | 0.0400 | 0.0500 | 0.0050 * | 0.0090 | 0.0260 | 0.0224 |
| Mg (mg/L) | 13.00 | 11.00 | 12.00 | 11.00 | 11.75 | 0.96 |
| Mo (mg/L) | 0.0060 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0034 | 0.0018 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0050 * | 0.0050 * | 0.0100 | 0.0071 |
| Sr (mg/L) | 0.1600 | 0.1500 | 0.1500 | 0.1300 | 0.1475 | 0.0126 |
| V (mg/L) | 0.0200 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0125 | 0.0050 |

* reported concentration = MDL/2

TABLE F.2.5-b

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| DATE: 1989 | JAN10 | JAN11 | JAN12 | JAN13 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0025 * | 0.0090 | 0.0025 * | 0.0090 | 0.0058 | 0.0038 |
| Ni (mg/L) | 0.1100 | 0.1200 | 0.2100 | 0.2200 | 0.1650 | 0.0580 |
| Pb (mg/L) | 0.0050 * | 0.0050 | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0900 | 0.0900 | 0.0600 | 0.0500 | 0.0725 | 0.0206 |
| Fe (mg/L) | 0.0920 | 0.0520 | 0.0100 * | 0.0640 | 0.0545 | 0.0341 |
| Mn (mg/L) | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0425 | 0.0050 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0700 | 0.0300 | 0.0100 * | 0.0400 | 0.0375 | 0.0250 |
| As (mg/L) | 0.0100 | 0.0300 | 0.0050 * | 0.0050 * | 0.0125 | 0.0119 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 55.00 | 48.12 | 48.60 | 46.70 | 49.61 | 3.69 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0060 | 0.0120 | 0.0140 | 0.0150 | 0.0118 | 0.0040 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0600 | 0.0500 | 0.0500 | 0.0300 | 0.0475 | 0.0126 |
| Mg (mg/L) | 12.00 | 11.00 | 11.00 | 11.00 | 11.25 | 0.50 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0050 * | 0.0050 * | 0.0100 | 0.0071 |
| Sr (mg/L) | 0.1500 | 0.1400 | 0.1300 | 0.1300 | 0.1375 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.5-c

## EFFLUENT CHEMICAL QUALITY - MIDLAND

| | | | 1 PM | 7 PM | MIDNITE | 8 AM | | |
|---|---|---|---|---|---|---|---|---|
| DATE: 1989 | JAN10 | JAN11 | JAN12 | JAN12 | JAN12 | JAN13 | AVG. | STD.DV. |
| GRAB - NON-FILTERED | | | | | | | | |
| SS (mg/L) | 6.1 | 6.6 | 6.0 | 6.4 | 7.2 | 5.1 | 6.2 | 0.7 |
| VSS (mg/L) | 3.7 | 4.5 | 3.9 | 4.8 | 4.8 | 4.7 | 4.4 | 0.5 |
| Ammon (mg/L) | 9.00 | 8.30 | 4.25 | 8.05 | 7.75 | 6.80 | 7.36 | 1.68 |
| Nitrate (mg/L) | 2.75 | 4.20 | 6.45 | 4.10 | 3.95 | 4.65 | 4.35 | 1.21 |
| Nitrite (mg/L) | 0.400 | 0.670 | 1.430 | 0.590 | 0.625 | 0.610 | 0.721 | 0.360 |
| BOD (mg/L) | 22.4 | 21.2 | 30.3 | 25.6 | 30.2 | 25.8 | 25.9 | 3.8 |
| DOC (mg/L) | 4.9 | 4.4 | 4.1 | 5.3 | 5.3 | 4.9 | 4.8 | 0.5 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| | | | | | | | | |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0160 | 0.0080 | 0.0025 * | 0.0025 * | 0.0057 | 0.0000 |
| Ni (mg/L) | 0.1200 | 0.1300 | 0.2100 | 0.2300 | 0.2400 | 0.2100 | 0.1900 | 0.0518 |
| Pb (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0075 | 0.0000 |
| Zn (mg/L) | 0.1000 | 0.0700 | 0.0800 | 0.0500 | 0.0600 | 0.0300 | 0.0650 | 0.0243 |
| Fe (mg/L) | 0.6800 | 0.5150 | 0.6000 | 0.4300 | 0.5100 | 0.5200 | 0.5425 | 0.0862 |
| Mn (mg/L) | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0417 | 0.0041 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1400 | 0.0900 | 0.1000 | 0.0800 | 0.1000 | 0.0800 | 0.0983 | 0.0223 |
| As (mg/L) | 0.0100 | 0.0200 | 0.0050 * | 0.0050 * | 0.0200 | 0.0200 | 0.0133 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 58.00 | 50.54 | 48.12 | 47.00 | 49.19 | 51.30 | 50.69 | 3.91 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0070 | 0.0025 * | 0.0130 | 0.0110 | 0.0110 | 0.0120 | 0.0094 | 0.0040 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0060 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0031 | 0.0014 |
| Hg (ug/L) | 0.0500 | 0.0400 | 0.0050 * | 0.0050 * | 0.0300 | 0.0200 | 0.0250 | 0.0184 |
| Mg (mg/L) | 13.00 | 12.00 | 11.00 | 11.00 | 12.00 | 12.00 | 11.83 | 0.75 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0100 | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0108 | 0.0074 |
| Sr (mg/L) | 0.1600 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1433 | 0.0082 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.5-d

## EFFLUENT CHEMICAL QUALITY - MIDLAND

|  |  |  |  | 1 PM | 7 PM | MIDNITE | 8 AM |  |  |
|---|---|---|---|---|---|---|---|---|---|
| DATE: | 1989 | JAN10 | JAN11 | JAN12 | JAN12 | JAN12 | JAN13 | AVG. | STD.DV. |
| GRAB - FILTERED |  |  |  |  |  |  |  |  |  |
| SS (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| VSS (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| Ammon (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| Nitrate (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| Nitrite (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| BOD (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| DOC (mg/L) |  | NA | NA | NA | NA | NA | NA |  |  |
| Cu (mg/L) |  | 0.0080 | 0.0090 | 0.0090 | 0.0060 | 0.0025 * | 0.0050 | 0.0066 | 0.0026 |
| Ni (mg/L) |  | 0.1100 | 0.1200 | 0.2000 | 0.2300 | 0.2500 | 0.2000 | 0.1850 | 0.0575 |
| Pb (mg/L) |  | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0058 | 0.0020 |
| Zn (mg/L) |  | 0.1000 | 0.1000 | 0.0700 | 0.0600 | 0.0800 | 0.0500 | 0.0767 | 0.0207 |
| Fe (mg/L) |  | 0.0570 | 0.2400 | 0.0380 | 0.0440 | 0.0620 | 0.2300 | 0.1118 | 0.0958 |
| Mn (mg/L) |  | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0417 | 0.0041 |
| Ag (mg/L) |  | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) |  | 0.0800 | 0.0500 | 0.0500 | 0.0100 * | 0.0600 | 0.0600 | 0.0517 | 0.0232 |
| As (mg/L) |  | 0.0200 | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0108 | 0.0000 |
| Be (mg/L) |  | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) |  | 57.00 | 48.63 | 46.90 | 47.38 | 51.38 | 50.00 | 50.22 | 4.15 |
| Cd (mg/L) |  | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) |  | 0.0050 | 0.0110 | 0.0140 | 0.0110 | 0.0130 | 0.0120 | 0.0110 | 0.0032 |
| Cr (mg/L) |  | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | ERR |
| Hg (ug/L) |  | 0.0500 | 0.0700 | 0.0700 | 0.0500 | 0.0300 | 0.0500 | 0.0533 | 0.0151 |
| Mg (mg/L) |  | 12.00 | 11.50 | 11.00 | 11.00 | 12.00 | 12.00 | 11.58 | 0.49 |
| Mo (mg/L) |  | 0.0025 * | 0.0050 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0029 | 0.0000 |
| Se (mg/L) |  | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0200 | 0.0075 | 0.0061 |
| Sr (mg/L) |  | 0.1600 | 0.1400 | 0.1300 | 0.1400 | 0.1400 | 0.1500 | 0.1433 | 0.0103 |
| V (mg/L) |  | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.6-a

## EFFLUENT CHEMICAL QUALITY - NORTH TORONTO

| DATE: 1989 | MAR15 | MAR16 | MAR17 | MAR18 | AVG. | STD.DEV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 36.0 | 33.0 | 33.0 | 30.0 | 33.0 | 2.4 |
| VSS (mg/L) | 18.0 | 20.0 | 10.0 | 6.0 | 13.5 | 6.6 |
| Ammon (mg/L) | 0.55 | 0.80 | 1.60 | 1.35 | 1.08 | 0.48 |
| Nitrate (mg/L) | 19.60 | 21.30 | 20.50 | 17.70 | 19.78 | 1.55 |
| Nitrite (mg/L) | 3.400 | 2.750 | 1.690 | 1.120 | 2.240 | 1.027 |
| BOD (mg/L) | 25.5 | | 18.3 | 14.9 | 19.6 | 5.4 |
| DOC (mg/L) | 8.0 | 6.6 | 6.3 | 6.2 | 6.8 | 0.8 |
| TRC (mg/L) | 0.17 | 0.20 | 0.18 | 0.22 | 0.19 | 0.02 |
| Cu (mg/L) | 0.0370 | 0.0480 | 0.0460 | 0.0440 | 0.0438 | 0.0048 |
| Ni (mg/L) | 0.0160 | 0.0190 | 0.0150 | 0.0230 | 0.0183 | 0.0036 |
| Pb (mg/L) | 0.0050 * | 0.0100 | 0.0200 | 0.0050 * | 0.0100 | 0.0071 |
| Zn (mg/L) | 0.0700 | 0.0800 | 0.0600 | 0.0600 | 0.0675 | 0.0096 |
| Fe (mg/L) | 5.3000 | 5.6000 | 5.1000 | 4.9000 | 5.2250 | 0.2986 |
| Mn (mg/L) | 0.0600 | 0.0600 | 0.0700 | 0.0700 | 0.0650 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0300 | 0.2300 | 0.0900 | 0.0800 | 0.1075 | 0.0858 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 50.45 | 192.00 | 188.00 | 192.00 | 155.61 | 70.13 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0080 | 0.0070 | 0.0070 | 0.0061 | 0.0025 |
| Hg (ug/L) | 0.1100 | 0.0050 * | 0.1300 | 0.0700 | 0.0788 | 0.0551 |
| Mg (mg/L) | 9.60 | 11.00 | 10.50 | 11.00 | 10.53 | 0.66 |
| Mo (mg/L) | 0.0150 | 0.0170 | 0.0160 | 0.0170 | 0.0163 | 0.0010 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2100 | 0.2300 | 0.2300 | 0.2300 | 0.2250 | 0.0100 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.6-b

## EFFLUENT CHEMICAL QUALITY - NORTH TORONTO

| DATE: 1989 | MAR15 | MAR16 | MAR17 | MAR18 | AVG. | STD.DEV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0300 | 0.0290 | 0.0240 | 0.0250 | 0.0270 | 0.0029 |
| Ni (mg/L) | 0.0180 | 0.0190 | 0.0150 | 0.0230 | 0.0188 | 0.0033 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0600 | 0.0600 | 0.0500 | 0.0500 | 0.0550 | 0.0058 |
| Fe (mg/L) | 0.0100 * | 0.1600 | 0.1000 | 0.0760 | 0.0865 | 0.0620 |
| Mn (mg/L) | 0.0500 | 0.0500 * | 0.0600 | 0.0600 | 0.0550 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0100 * | 0.0600 | 0.0100 * | 0.0225 | 0.0250 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 50.70 | 190.00 | 183.00 | 185.00 | 152.18 | 67.71 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.1200 | 0.0050 * | 0.0050 * | 0.0425 | 0.0542 |
| Mg (mg/L) | 9.70 | 11.00 | 10.00 | 11.00 | 10.43 | 0.68 |
| Mo (mg/L) | 0.0140 | 0.0150 | 0.0120 | 0.0150 | 0.0140 | 0.0014 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Sr (mg/L) | 0.2100 | 0.2300 | 0.2100 | 0.2200 | 0.2175 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.7-a

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1990 | FEB21 | FEB22 | FEB23 | FEB24 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 24.1 | 17.7 | 16.3 | 15.7 | 18.5 | 3.9 |
| VSS (mg/L) | 21.8 | 16.7 | 13.0 | 14.7 | 16.6 | 3.8 |
| Ammon (mg/L) | 8.25 | 8.25 | 8.30 | 8.30 | 8.28 | 0.03 |
| Nitrate (mg/L) | 0.03 * | 0.03 * | 0.50 | 0.10 | 0.16 | 0.23 |
| Nitrite (mg/L) | 0.055 | 0.005 | 0.005 | 0.005 | 0.018 | 0.025 |
| BOD (mg/L) | 39.9 | 31.9 | 21.1 | 21.0 | 28.5 | 9.17 |
| DOC (mg/L) | 13.7 | 13.2 | 13.5 | 13.6 | 13.5 | 0.2 |
| Sulphide (mg/L) | 4.7 | 5.0 | 4.5 | 5.0 | 4.8 | 0.2 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Ni (mg/L) | 0.0200 | 0.0120 | 0.0130 | 0.0050 * | 0.0125 | 0.0061 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Fe (mg/L) | 0.1200 | 0.1350 | 0.1300 | 0.0100 * | 0.0988 | 0.0595 |
| Mn (mg/L) | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.7400 | 0.7500 | 0.7300 | 0.8900 | 0.7775 | 0.0754 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 62.84 | 60.72 | 58.28 | 95.45 | 69.32 | 17.52 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0050 | 0.0031 | 0.0013 |
| Hg (ug/L) | 0.0300 | 0.0100 * | 0.0100 * | 0.0100 * | 0.0150 | 0.0100 |
| Mg (mg/L) | 11.00 | 10.50 | 10.00 | 11.00 | 10.63 | 0.48 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0200 | 0.0050 * | 0.0100 | 0.0100 | 0.0113 | 0.0063 |
| Sr (mg/L) | 0.3800 | 0.3600 | 0.3500 | 0.4000 | 0.3725 | 0.0222 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.7-b

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: | 1990 FEB21 | FEB22 | FEB23 | FEB24 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Ni (mg/L) | 0.0160 | 0.0130 | 0.0140 | 0.0050 * | 0.0120 | 0.0048 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0200 | 0.0100 | 0.0200 * | 0.0200 | 0.0175 | 0.0050 |
| Fe (mg/L) | 0.0900 | 0.0850 | 0.0820 | 0.0480 | 0.0763 | 0.0191 |
| Mn (mg/L) | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0600 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.2300 | 0.2400 | 0.2500 | 0.3300 | 0.2625 | 0.0457 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 62.87 | 59.33 | 60.39 | 60.58 | 60.79 | 1.49 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.0400 | 0.0200 * | 0.0100 * | 0.0275 | 0.0150 |
| Mg (mg/L) | 11.00 | 10.00 | 10.00 | 11.00 | 10.50 | 0.58 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0200 | 0.0125 | 0.0050 * | 0.0050 * | 0.0106 | 0.0072 |
| Sr (mg/L) | 0.4000 | 0.3500 | 0.3600 | 0.4000 | 0.3775 | 0.0263 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.7-c

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1990 | FEB21 | FEB22 | FEB23 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| **GRAB - NON-FILTERED** | | | | | |
| SS (mg/L) | 21.9 | 17.1 | 15.6 | 18.2 | 3.3 |
| VSS (mg/L) | 19.9 | 14.3 | 14.3 | 16.2 | 3.2 |
| Ammon (mg/L) | 8.20 | 8.25 | 8.45 | 8.30 | 0.1 |
| Nitrate (mg/L) | 0.03 * | 0.03 * | 0.03 * | 0.03 | 0.0 |
| Nitrite (mg/L) | 0.005 | 0.005 | 0.005 | 0.005 | 0.0 |
| BOD (mg/L) | 37.5 | 41.7 | 18.5 | 32.6 | 12.4 |
| DOC (mg/L) | 13.5 | 13.5 | 13.5 | 13.5 | 0.0 |
| Sulphide (mg/L) | 5.5 | 10.6 | 10.8 | 9.0 | 3.0 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0025 * | 0.0025 * | 0.0250 * | 0.0100 | 0.0130 |
| Ni (mg/L) | 0.0140 | 0.0150 | 0.0170 | 0.0153 | 0.0015 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Fe (mg/L) | 0.0920 | 0.1150 | 0.1200 | 0.1090 | 0.0149 |
| Mn (mg/L) | 0.0600 | 0.0600 * | 0.0600 | 0.0600 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.7200 | 0.7600 | 0.7500 | 0.7433 | 0.0208 |
| As (mg/L) | 0.0050 * | 0.0425 | 0.0050 * | 0.0175 | 0.0217 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 57.60 | 61.59 | 62.09 | 60.43 | 2.46 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0300 | 0.0200 | 0.0500 | 0.0333 | 0.0153 |
| Mg (mg/L) | 10.00 | 11.00 | 11.00 | 10.67 | 0.58 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0200 | 0.0200 | 0.0100 | 0.0167 | 0.0058 |
| Sr (mg/L) | 0.3500 | 0.3700 | 0.3700 | 0.3633 | 0.0115 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.7-d

## EFFLUENT CHEMICAL QUALITY - PERTH

| DATE: 1990 | FEB21 | FEB22 | FEB23 | AVG. | STD.DV. |
|---|---|---|---|---|---|
| GRAB - FILTERED | | | | | |
| SS (mg/L) | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | | |
| Cu (mg/L) | 0.0060 | 0.0025 * | 0.0025 * | 0.0037 | 0.0020 |
| Ni (mg/L) | 0.0190 | 0.1030 | 0.0050 | 0.0423 | 0.0530 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0200 | 0.0150 | 0.0100 * | 0.0150 | 0.0050 |
| Fe (mg/L) | 0.1200 | 0.0660 | 0.0760 | 0.0873 | 0.0287 |
| Mn (mg/L) | 0.0700 | 0.0600 | 0.0600 | 0.0633 | 0.0058 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.2700 | 0.2700 | 0.2500 | 0.2633 | 0.0115 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 62.13 | 61.64 | 62.60 | 62.12 | 0.48 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.0450 | 0.0300 | 0.0383 | 0.0076 |
| Mg (mg/L) | 11.00 | 11.00 | 11.00 | 11.00 | 0.00 |
| Mo (mg/L) | 0.0070 | 0.0025 * | 0.0025 * | 0.0040 | 0.0026 |
| Se (mg/L) | 0.0100 | 0.0050 * | 0.0100 | 0.0083 | 0.0029 |
| Sr (mg/L) | 0.3800 | 0.3700 | 0.3700 | 0.3733 | 0.0058 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.8-a

## EFFLUENT CHEMICAL QUALITY - STRATFORD

| DATE: 1990 | FEB14 | FEB15 | FEB16 | FEB17 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 0.8 | 1.7 | 0.6 | 1.3 | 1.1 | 0.5 |
| VSS (mg/L) | 0.8 | 1.5 | 0.5 | 1.3 | 1.0 | 0.5 |
| Ammon (mg/L) | 7.75 | 7.5 | 8.6 | 9.45 | 8.33 | 0.89 |
| Nitrate (mg/L) | 5.15 | 5.05 | 4.45 | 3.45 | 4.53 | 0.78 |
| Nitrite (mg/L) | 0.710 | 0.610 | 0.650 | 0.505 | 0.62 | 0.086 |
| BOD (mg/L) | 10.6 | 7.6 | 12.9 | 10.1 | 10.3 | 2.2 |
| DOC (mg/L) | 5.3 | 5.4 | 5.4 | 5.6 | 5.4 | 0.1 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0090 | 0.0060 | 0.0170 | 0.0100 | 0.0105 | 0.0047 |
| Ni (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0200 | 0.0200 | 0.0300 | 0.0250 | 0.0058 |
| Fe (mg/L) | 0.0920 | 0.0530 | 0.0620 | 0.0580 | 0.0663 | 0.0176 |
| Mn (mg/L) | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.1000 * | 0.0500 * | 0.1000 * | 0.0750 | 0.0289 |
| Al (mg/L) | 0.0400 | 0.0100 | 0.1000 | 0.0500 | 0.0500 | 0.0374 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 * | 0.0063 | 0.0025 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 119.70 | 126.70 | 119.10 | 120.30 | 121.45 | 3.53 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0400 | 0.0200 * | 0.0100 * | 0.0300 | 0.0250 | 0.0129 |
| Mg (mg/L) | 21.00 | 21.00 | 20.00 | 21.00 | 20.75 | 0.50 |
| Mo (mg/L) | 0.0050 | 0.0060 | 0.0070 | 0.0060 | 0.0060 | 0.0008 |
| Se (mg/L) | 0.0050 * | 0.0200 | 0.0200 | 0.0050 * | 0.0125 | 0.0087 |
| Sr (mg/L) | 6.90 | 7.00 | 7.00 | 7.10 | 7.00 | 0.08 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0200 * | 0.0100 * | 0.0125 | 0.0050 |

* reported concentration = MDL/2

TABLE F.2.8-b

## EFFLUENT CHEMICAL QUALITY - STRATFORD

| DATE: 1990 | FEB14 | FEB15 | FEB16 | FEB17 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0070 | 0.0060 | 0.0170 | 0.0080 | | |
| Ni (mg/L) | 0.0110 | 0.0050 * | 0.0120 | 0.0050 * | 0.0095 | 0.0051 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0050 * | 0.0083 | 0.0038 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0400 | 0.0200 | 0.0063 | 0.0025 |
| Fe (mg/L) | 0.0530 | 0.0400 | 0.0620 | 0.1000 | 0.0300 | 0.0082 |
| Mn (mg/L) | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0638 | 0.0258 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0500 | 0.0600 | 0.0800 | 0.0700 | 0.0500 | 0.0000 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0650 | 0.0129 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 119.70 | 123.30 | 121.60 | 115.70 | 0.0050 | 0.0000 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 120.08 | 3.27 |
| Co (mg/L) | 0.0050 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0050 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0031 | 0.0012 |
| Hg (ug/L) | 0.1100 | 0.0500 | 0.0500 | 0.0400 | 0.0025 | 0.0000 |
| Mg (mg/L) | 21.00 | 21.00 | 21.00 | 20.00 | 0.0625 | 0.0320 |
| Mo (mg/L) | 0.0060 | 0.0070 | 0.0070 | 0.0060 | 20.75 | 0.50 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0100 * | 0.0065 | 0.0006 |
| Sr (mg/L) | 6.90 | 7.00 | 7.10 | 7.10 | 0.0063 | 0.0025 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 7.03 | 0.10 |
| | | | | | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.9-a

## EFFLUENT CHEMICAL QUALITY - WALKERTON

| DATE: 1990 | JAN17 | JAN18 | JAN19 | JAN20 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - NON-FILTERED | | | | | | |
| SS (mg/L) | 5.9 | 4.4 | 7.2 | 3.9 | 5.4 | 1.5 |
| VSS (mg/L) | 3.1 | 3.7 | 6.2 | 3.9 | 4.2 | 1.4 |
| Ammon (mg/L) | 0.60 | 2.15 | 0.65 | 0.65 | 1.01 | 0.76 |
| Nitrate (mg/L) | 19.50 | 12.05 | 12.10 | 12.90 | 14.14 | 3.60 |
| Nitrite (mg/L) | 0.815 | 0.808 | 0.870 | 0.810 | 0.826 | 0.030 |
| BOD (mg/L) | 5.2 | 7.9 | 8.3 | 4.6 | 6.5 | 1.9 |
| DOC (mg/L) | 4.5 | 4.6 | 4.2 | 3.7 | 4.3 | 0.4 |
| TRC (mg/L) | 0.005 * | 0.005 * | 0.005 * | 0.005 * | 0.005 | 0.000 |
| Cu (mg/L) | 0.0400 | 0.0230 | 0.0190 | 0.0180 | 0.0250 | 0.0102 |
| Ni (mg/L) | 0.0540 | 0.0320 | 0.0330 | 0.0340 | 0.0383 | 0.0105 |
| Pb (mg/L) | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0063 | 0.0025 |
| Zn (mg/L) | 0.0500 | 0.0300 | 0.0300 | 0.0300 | 0.0350 | 0.0100 |
| Fe (mg/L) | 0.2700 | 0.1650 | 0.3300 | 0.1700 | 0.2338 | 0.0804 |
| Mn (mg/L) | 0.0500 | 0.0400 | 0.0400 | 0.0300 | 0.0400 | 0.0082 |
| Ag (mg/L) | 0.0500 * | 0.0500 | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1300 | 0.0700 | 0.1200 | 0.0800 | 0.1000 | 0.0294 |
| As (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 188.00 | 138.60 | 164.00 | 167.30 | 164.48 | 20.26 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0043 | 0.0060 | 0.0025 * | 0.0038 | 0.0017 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0050 * | 0.0075 | 0.0100 | 0.0100 * | 0.0081 | 0.0024 |
| Mg (mg/L) | 24.00 | 19.00 | 21.00 | 22.00 | 21.50 | 2.08 |
| Mo (mg/L) | 0.0060 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0034 | 0.0018 |
| Se (mg/L) | 0.0200 | 0.0100 | 0.0100 | 0.0050 * | 0.0113 | 0.0063 |
| Sr (mg/L) | 7.3000 | 5.4500 | 5.3000 | 5.6000 | 5.9125 | 0.9331 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.9-b

## EFFLUENT CHEMICAL QUALITY - WALKERTON

| DATE: 1990 | JAN17 | JAN18 | JAN19 | JAN20 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| COMPOSITES - FILTERED | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0340 | 0.0190 | 0.0140 | 0.0100 | 0.0193 | 0.0105 |
| Ni (mg/L) | 0.0510 | 0.0330 | 0.0360 | 0.0360 | 0.0390 | 0.0081 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0500 | 0.0500 | 0.0500 | 0.0400 | 0.0475 | 0.0050 |
| Fe (mg/L) | 0.0320 | 0.0340 | 0.0100 * | 0.0100 * | 0.0215 | 0.0133 |
| Mn (mg/L) | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0000 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0800 | 0.0900 | 0.0900 | 0.0700 | 0.0825 | 0.0096 |
| As (mg/L) | 0.0200 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0088 | 0.0075 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 172.70 | 150.95 | 157.80 | 185.00 | 166.61 | 15.25 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0080 * | 0.0025 * | 0.0100 | 0.0150 | 0.0089 | 0.0052 |
| Cr (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Hg (ug/L) | 0.0600 | 0.0900 | 0.0700 | 0.0300 | 0.0625 | 0.0250 |
| Mg (mg/L) | 22.00 | 20.00 | 21.00 | 23.00 | 21.50 | 1.29 |
| Mo (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Se (mg/L) | 0.0200 | 0.0100 | 0.0100 | 0.0050 * | 0.0113 | 0.0063 |
| Sr (mg/L) | 7.1000 | 5.8500 | 5.2000 | 5.9000 | 6.0125 | 0.7920 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.10-a

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1990 | JAN24 | JAN25 | JAN26 | JAN27 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - NON-FILTERED** | | | | | | |
| SS (mg/L) | 11.4 | 17.2 | 18.0 | 15.7 | 15.6 | 2.9 |
| VSS (mg/L) | 8.6 | 13.0 | 13.4 | 12.3 | 11.8 | 2.2 |
| Ammon (mg/L) | 12.50 | 14.30 | 17.70 | 13.00 | 14.38 | 2.34 |
| Nitrate (mg/L) | 5.65 | 4.45 | 2.90 | 3.45 | 4.11 | 1.21 |
| Nitrite (mg/L) | 0.695 | 1.830 | 0.460 | 0.545 | 0.883 | 0.639 |
| BOD (mg/L) | 8.6 | 17.2 | 11.0 | 9.9 | 11.7 | 3.8 |
| DOC (mg/L) | 14.9 | 17.8 | 17.4 | 18.2 | 17.1 | 1.5 |
| TRC (mg/L) | 0.34 | 0.18 | 0.08 | 0.16 | 0.19 | 0.11 |
| Cu (mg/L) | 0.0900 | 0.0830 | 0.0870 | 0.1000 | 0.0900 | 0.0073 |
| Ni (mg/L) | 0.0410 | 0.0360 | 0.0480 | 0.0530 | 0.0445 | 0.0075 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0400 | 0.0100 | 0.0300 | 0.0300 | 0.0275 | 0.0126 |
| Fe (mg/L) | 0.8600 | 1.6000 | 1.4000 | 1.2000 | 1.2650 | 0.3155 |
| Mn (mg/L) | 0.0900 | 0.0800 | 0.0900 | 0.1000 | 0.0900 | 0.0082 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0500 | 0.0900 | 0.0800 | 0.0700 | 0.0725 | 0.0171 |
| As (mg/L) | 0.0050 * | 0.0200 | 0.0100 | 0.0100 | 0.0113 | 0.0063 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 85.80 | 78.45 | 87.60 | 83.70 | 83.89 | 3.96 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0150 | 0.0160 | 0.0210 | 0.0180 | 0.0175 | 0.0026 |
| Hg (ug/L) | 0.0600 | 0.0400 | 0.0600 | 0.0400 | 0.0500 | 0.0115 |
| Mg (mg/L) | 13.00 | 13.00 | 14.00 | 14.00 | 13.50 | 0.58 |
| Mo (mg/L) | 0.0070 | 0.0080 | 0.0080 | 0.0060 | 0.0073 | 0.0010 |
| Se (mg/L) | 0.0200 | 0.0050 * | 0.0100 | 0.0200 | 0.0138 | 0.0075 |
| Sr (mg/L) | 0.2600 | 0.2400 | 0.2700 | 0.2600 | 0.2575 | 0.0126 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.10-b

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1990 | JAN24 | JAN25 | JAN26 | JAN27 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|
| **COMPOSITES - FILTERED** | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.0880 | 0.0770 | 0.0720 | 0.0820 | 0.0798 | 0.0068 |
| Ni (mg/L) | 0.0400 | 0.0330 | 0.0500 | 0.0420 | 0.0413 | 0.0070 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0400 | 0.0300 | 0.0500 | 0.0500 | 0.0425 | 0.0096 |
| Fe (mg/L) | 0.1300 | 0.8750 | 0.2100 | 0.0690 | 0.3210 | 0.3738 |
| Mn (mg/L) | 0.0900 | 0.0700 | 0.0900 | 0.0900 | 0.0850 | 0.0100 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0300 | 0.0500 | 0.0500 | 0.0300 | 0.0400 | 0.0115 |
| As (mg/L) | 0.0050 * | 0.0200 | 0.0100 | 0.0100 | 0.0113 | 0.0063 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 89.50 | 78.40 | 85.00 | 79.60 | 83.13 | 5.13 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0025 * | 0.0060 | 0.0070 | 0.0025 * | 0.0045 | 0.0023 |
| Hg (ug/L) | 0.0900 | 0.1200 | 0.2400 | 0.1200 | 0.1425 | 0.0665 |
| Mg (mg/L) | 14.00 | 13.00 | 14.00 | 13.00 | 13.50 | 0.58 |
| Mo (mg/L) | 0.0070 | 0.0100 | 0.0080 | 0.0050 | 0.0075 | 0.0021 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0075 | 0.0029 |
| Sr (mg/L) | 0.2700 | 0.2500 | 0.2600 | 0.2500 | 0.2575 | 0.0096 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2
NA - not analyzed

TABLE F.2.10-c

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1990 | JAN24 | JAN25 | 1 PM JAN26 | 7 PM JAN26 | MIDNITE JAN26 | 8 AM JAN27 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|---|---|
| GRAB - NON-FILTERED | | | | | | | | |
| SS (mg/L) | 12.6 | 15.1 | 8.8 | 12.7 | 16.4 | 11.6 | 12.9 | 2.7 |
| VSS (mg/L) | 9.6 | 11.5 | 6.7 | 9.4 | 11.7 | 8.9 | 9.6 | 1.8 |
| Ammon (mg/L) | 11.10 | 13.85 | 9.75 | 14.70 | 13.70 | 12.2 | 12.55 | 1.88 |
| Nitrate (mg/L) | 4.65 | 2.15 | 4.25 | 3.75 | 3.60 | 1.55 | 3.33 | 1.22 |
| Nitrite (mg/L) | 0.550 | 0.535 | 0.475 | 0.595 | 0.570 | 0.490 | 0.536 | 0.046 |
| BOD (mg/L) | 9.1 | 13.5 | 6.1 | 10.8 | 12.4 | 8.5 | 10.1 | 2.7 |
| DOC (mg/L) | 16.5 | 18.2 | 16.9 | 17.8 | 18.2 | 19.3 | 17.8 | 1.0 |
| TRC (mg/L) | 0.53 | 0.49 | 0.005 * | 0.06 | 0.14 | 0.98 | 0.368 | 0.373 |
| Cu (mg/L) | 0.1500 | 0.0790 | 0.1100 | 0.0840 | 0.0890 | 0.0900 | 0.1003 | 0.0265 |
| Ni (mg/L) | 0.0410 | 0.0385 | 0.0550 | 0.0570 | 0.0520 | 0.0430 | 0.0478 | 0.0079 |
| Pb (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Zn (mg/L) | 0.0300 | 0.0200 | 0.0200 | 0.0300 | 0.0400 | 0.0400 | 0.0300 | 0.0089 |
| Fe (mg/L) | 1.3000 | 1.1500 | 0.7500 | 1.1000 | 1.3000 | 1.1000 | 1.1167 | 0.2017 |
| Mn (mg/L) | 0.1000 | 0.1000 | 0.1000 | 0.0900 | 0.0900 | 0.0900 | 0.0950 | 0.0055 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.1000 | 0.0350 | 0.0600 | 0.0500 | 0.1600 | 0.0800 | 0.0808 | 0.0450 |
| As (mg/L) | 0.0100 | 0.0050 * | 0.0100 | 0.0100 | 0.0100 | 0.0100 | 0.0092 | 0.0020 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 92.90 | 89.70 | 87.90 | 81.10 | 79.90 | 80.40 | 85.317 | 5.56 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.005 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.003 | 0.0000 |
| Cr (mg/L) | 0.0190 | 0.0180 | 0.0130 | 0.0180 | 0.0200 | 0.0160 | 0.017 | 0.0025 |
| Hg (ug/L) | 0.0300 | 0.0400 | 0.0500 | 0.0500 | 0.0500 | 0.0400 | 0.043 | 0.0082 |
| Mg (mg/L) | 14.00 | 14.00 | 14.00 | 14.00 | 13.00 | 14.00 | 13.833 | 0.41 |
| Mo (mg/L) | 0.0090 | 0.0090 | 0.0070 | 0.0070 | 0.0070 | 0.0090 | 0.008 | 0.0011 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0100 | 0.0100 | 0.008 | 0.0026 |
| Sr (mg/L) | 0.2900 | 0.2750 | 0.2800 | 0.2500 | 0.2500 | 0.2500 | 0.266 | 0.0180 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.010 | 0.0000 |

* reported concentration = MDL/2

TABLE F.2.10-d

## EFFLUENT CHEMICAL QUALITY - WALLACEBURG

| DATE: 1990 | JAN24 | JAN25 | 1 PM JAN26 | 8 PM JAN25 | MIDNITE JAN26 | 8 AM JAN27 | AVG. | STD.DV. |
|---|---|---|---|---|---|---|---|---|
| **GRAB - FILTERED** | | | | | | | | |
| SS (mg/L) | NA | NA | NA | NA | NA | NA | | |
| VSS (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Ammon (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Nitrate (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Nitrite (mg/L) | NA | NA | NA | NA | NA | NA | | |
| BOD (mg/L) | NA | NA | NA | NA | NA | NA | | |
| DOC (mg/L) | NA | NA | NA | NA | NA | NA | | |
| Cu (mg/L) | 0.1300 | 0.0700 | 0.0870 | 0.0750 | 0.0790 | 0.0820 | 0.0872 | 0.0218 |
| Ni (mg/L) | 0.0370 | 0.0360 | 0.0610 | 0.0500 | 0.0440 | 0.0390 | 0.0445 | 0.0096 |
| Pb (mg/L) | 0.0050 * | 0.0100 | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0058 | 0.0020 |
| Zn (mg/L) | 0.0300 | 0.0300 | 0.0400 | 0.0500 | 0.0600 | 0.0400 | 0.0417 | 0.0117 |
| Fe (mg/L) | 0.1400 | 0.3200 | 0.0770 | 0.0610 | 0.0650 | 0.1000 | 0.1272 | 0.0988 |
| Mn (mg/L) | 0.0900 | 0.0900 | 0.1000 | 0.0900 | 0.0900 | 0.1000 | 0.0933 | 0.0052 |
| Ag (mg/L) | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 * | 0.0500 | 0.0000 |
| Al (mg/L) | 0.0100 * | 0.0350 | 0.0100 | 0.0300 | 0.0100 * | 0.0300 | 0.0208 | 0.0120 |
| As (mg/L) | 0.0200 | 0.0125 * | 0.0100 | 0.0100 | 0.0100 | 0.0100 | 0.0121 | 0.0040 |
| Be (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Ca (mg/L) | 90.70 | 88.70 | 92.30 | 81.40 | 79.10 | 83.40 | 85.9333 | 5.38 |
| Cd (mg/L) | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 * | 0.0050 | 0.0000 |
| Co (mg/L) | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 * | 0.0025 | 0.0000 |
| Cr (mg/L) | 0.0060 | 0.0043 | 0.0025 | 0.0025 * | 0.0025 * | 0.0025 * | 0.0034 | 0.0015 |
| Hg (ug/L) | 0.0500 | 0.1300 | 0.1600 | 0.0500 | 0.0300 | 0.2000 | 0.1033 | 0.0698 |
| Mg (mg/L) | 14.00 | 14.00 | 15.00 | 14.00 | 13.00 | 14.00 | 14.0000 | 0.63 |
| Mo (mg/L) | 0.0070 | 0.0095 | 0.0060 | 0.0025 * | 0.0060 | 0.0070 | 0.0063 | 0.0023 |
| Se (mg/L) | 0.0050 * | 0.0050 * | 0.0100 | 0.0100 | 0.0100 | 0.0100 | 0.0083 | 0.0026 |
| Sr (mg/L) | 0.2900 | 0.2700 | 0.2900 | 0.2600 | 0.2500 | 0.2600 | 0.2700 | 0.0167 |
| V (mg/L) | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 * | 0.0100 | 0.0000 |

* reported concentration = MDL/2

**Table F.3 Effluent Total Residual Chlorine Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory**

| | Concentration (mg/L) | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| Summer Sampling | | | | |
| Bracebridge | | | | |
| B2607C1 | 0.155 | 0.08 | -0.08 | -48 |
| B2707C2 | 0.185 | < 0.04 | > -0.15 | > -78 |
| B2807C3 | 0.170 | 0.11 | -0.06 | -35 |
| B2907C4 | 0.140 | 0.06 | -0.08 | -57 |
| Highland Creek | | | | |
| T0706C1 | 0.028 | < 0.01 | > -0.02 | > -64 |
| T0806C2 | 0.024 | < 0.01 | > -0.01 | > -58 |
| T0906C3 | 0.020 | < 0.01 | > -0.01 | > -50 |
| T1006C4 | 0.016 | < 0.01 | > -0.01 | > -38 |
| T0706G1 | 0.220 | < 0.01 | > -0.21 | > -95 |
| T0806G2 | 0.015 | < 0.01 | > -0.01 | > -33 |
| T0906G3 | 0.350 | 0.08 | -0.27 | -77 |
| T1006G4 | 0.250 | < 0.01 | > -0.24 | > -96 |
| Huntsville | | | | |
| H1608C1 | 0.542 | 0.51 | -0.03 | -6 |
| H1708C2 | 0.558 | 0.52 | -0.04 | -7 |
| H1808C3 | 0.591 | 0.58 | -0.01 | -2 |
| H1908C4 | 0.450 | 0.49 | 0.04 | 9 |
| Lindsay Plant Not Chlorinating | | | | |
| Midland | | | | |
| M1907C1 | 0.450 | 0.38 | -0.07 | -16 |
| M2007C2 | 0.550 | 0.43 | -0.12 | -22 |
| M2107C3 | 0.155 | < 0.02 | > -0.14 | > -87 |
| M2207C4 | 0.237 | 0.21 | -0.03 | -11 |
| M1907G1 | 0.620 | 0.56 | -0.06 | -10 |
| M2007G2 | 0.655 | 0.48 | -0.18 | -27 |
| M2107G3 | 0.605 | 0.57 | -0.04 | -6 |
| M2107G4 | 0.290 | 0.22 | -0.07 | -24 |
| M2107G5 | 0.320 | 0.32 | 0.00 | 0 |
| M2207G6 | 0.215 | 0.20 | -0.01 | -7 |
| North Toronto | | | | |
| N1406C1 | 0.400 | 0.33 | -0.07 | -18 |
| N1506C2 | 0.434 | 0.34 | -0.09 | -22 |
| N1606C3 | 0.450 | 0.29 | -0.16 | -36 |
| N1706C4 | 0.330 | 0.27 | -0.06 | -18 |
| Perth Plant Not Chlorinating | | | | |

Table F.3 Effluent Total Residual Chlorine Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | Concentration (mg/L) | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| **Stratford** | | | | |
| S1207C1 | < 0.020 | 0.01 | 0.00 | 0 |
| S1307C2 | < 0.020 | < 0.01 | 0.00 | 0 |
| S1407C3 | < 0.020 | < 0.01 | 0.00 | 0 |
| S1507C4 | < 0.020 | < 0.01 | 0.00 | 0 |
| **Walkerton** | | | | |
| W2106C1 | 0.165 | 0.115 | -0.05 | -30 |
| W2206C2 | 0.153 | 0.020 | -0.13 | -87 |
| W2306C3 | 0.095 | 0.020 | -0.08 | -79 |
| W2406C4 | 0.085 | 0.010 | -0.08 | -88 |
| **Wallaceburg** | | | | |
| G0609C1 | 0.295 | 0.14 | -0.15 | -53 |
| G0709C2 | 0.210 | 0.10 | -0.11 | -52 |
| G0809C3 | 0.116 | 0.08 | -0.04 | -31 |
| G0909C4 | 0.010 | < 0.01 | > 0.00 | > 0 |
| G0609G1 | 0.423 | 0.02 | -0.40 | -95 |
| G0709G2 | 0.342 | 0.15 | -0.19 | -56 |
| G0809G3 | 0.520 | 0.23 | -0.29 | -56 |
| G0909G4 | 0.620 | 0.07 | -0.55 | -89 |
| G0909G5 | 0.160 | 0.02 | -0.14 | -88 |
| G0909G6 | 0.179 | 0.22 | 0.04 | 23 |
| **Winter Sampling** | | | | |
| **Bracebridge** | | | | |
| B1212C1 | 0.02 | 0.02 | 0.00 | 0 |
| B1312C2 | 0.01 | < 0.01 | > 0.00 | > 0 |
| B1412C3 | 0.01 | < 0.01 | > 0.00 | > 0 |
| B1512C4 | < 0.01 | < 0.01 | > 0.00 | > 0 |
| **Highland Creek** | | | | |
| T2203C1 | * | 0.12 | * | * |
| T2303C2 | * | 0.03 | * | * |
| T2403C3 | 0.20 | 0.03 | -0.17 | -85 |
| T2503C4 | 0.02 | < 0.01 | > -0.01 | > -50 |
| T2203G1 | 0.33 | 0.26 | -0.07 | -21 |
| T2303G2 | * | < 0.01 | * | * |
| T2403G3 | 0.155 | 0.18 | 0.02 | 16 |
| T2503G4 | 0.74 | 0.24 | -0.50 | -68 |
| **Huntsville** | | | | |
| H0612C1 | 1.14 | 1.05 | -0.09 | -8 |
| H0712C2 | 1.14 | 1.09 | -0.05 | -4 |
| H0812C3 | 1.01 | 0.98 | -0.03 | -3 |
| H0912C4 | 0.724 | 0.67 | -0.05 | -7 |

**Table F.3** Effluent Total Residual Chlorine Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | Concentration (mg/L) | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| Lindsay | Plant Not Chlorinating | | | |
| Midland | Plant Not Chlorinating | | | |
| North Toronto | | | | |
| N1503C1 | 0.20 | 0.17 | -0.03 | -15 |
| N1603C2 | 0.30 | 0.2 | -0.10 | -33 |
| N1703C3 | 0.26 | 0.18 | -0.08 | -31 |
| N1803C4 | 0.35 | 0.22 | -0.13 | -37 |
| Perth | Plant Not Chlorinating | | | |
| Stratford | Plant Not Chlorinating | | | |
| Walkerton | Plant Not Chlorinating | | | |
| Wallaceburg | | | | |
| G2401C1 | 0.350 | 0.34 | -0.01 | -3 |
| G2501C2 | 0.215 | 0.18 | -0.04 | -16 |
| G2601C3 | 0.123 | 0.08 | -0.04 | -35 |
| G2701C4 | 0.215 | 0.16 | -0.06 | -26 |
| G2401G1 | 0.591 | 0.53 | -0.06 | -10 |
| G2501G2 | 0.541 | 0.49 | -0.05 | -9 |
| G2601G3 | < 0.020 | < 0.01 | 0.00 | 0 |
| G2601G4 | 0.295 | 0.06 | -0.24 | -80 |
| G2601G5 | 0.535 | 0.14 | -0.40 | -74 |
| G2701G6 | 1.2 | 0.98 | -0.22 | -18 |

* - Probe de-sensitized, therefore no reading obtained

Table F.4 Effluent Ammonia Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | -----Concentration (mg/L)----- | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| Summer Sampling | | | | |
| Bracebridge | | | | |
| B2607C1 | 6.1 | 6.6 | 0.50 | 8 |
| B2707C2 | 5.6 | 5.4 | -0.20 | -4 |
| B2807C3 | 4.2 | 4.0 | -0.20 | -5 |
| B2907C4 | 0.6 | 1.2 | 0.60 | 100 |
| Highland Creek | | | | |
| T0706C1 | 14.1 | 16.0 | 1.90 | 13 |
| T0806C2 | 14.4 | 16.8 | 2.40 | 17 |
| T0906C3 | 16.8 | 19.2 | 2.40 | 14 |
| T1006C4 | 12.0 | 19.2 | 7.20 | 60 |
| T0706G1 | 13.6 | 16.0 | 2.40 | 18 |
| T0806G2 | 14.8 | 20.4 | 5.60 | 38 |
| T0906G3 | 13.6 | 18.0 | 4.40 | 32 |
| T1006G4 | 11.2 | 17.2 | 6.00 | 54 |
| Huntsville | | | | |
| H1608C1 | 16.0 | 11.2 | -4.80 | -30 |
| H1708C2 | 14.5 | 11.0 | -3.50 | -24 |
| H1808C3 | 18.0 | 14.6 | -3.40 | -19 |
| H1908C4 | 15.5 | 11.0 | -4.50 | -29 |
| Lindsay | | | | |
| L2308C1 | 1.5 | 1.3 | -0.18 | -12 |
| L2408C2 | 1.4 | 1.2 | -0.16 | -11 |
| L2508C3 | 1.4 | 1.4 | -0.04 | -3 |
| L2608C4 | 1.5 | 1.4 | -0.14 | -9 |
| L2308G1 | 1.5 | 1.4 | -0.14 | -9 |
| L2408G2 | 1.4 | 1.3 | -0.12 | -9 |
| L2508G3 | 1.4 | 1.4 | -0.04 | -3 |
| Midland | | | | |
| M1907C1 | 14.4 | 9.0 | -5.40 | -38 |
| M2007C2 | 11.2 | 10.2 | -1.00 | -9 |
| M2107C3 | 10.8 | 11.4 | 0.60 | 6 |
| M2207C4 | 11.2 | 14.0 | 2.80 | 25 |
| M1907G1 | 11.2 | 11.4 | 0.20 | 2 |
| M2007G2 | 10.0 | 9.6 | -0.40 | -4 |
| M2107G3 | 8.4 | 9.0 | 0.60 | 7 |
| M2107G4 | 10.4 | 11.0 | 0.60 | 6 |
| M2107G5 | 13.6 | 17.6 | 4.00 | 29 |
| M2207G6 | 10.0 | 10.0 | 0.00 | 0 |

Table F.4 Effluent Ammonia Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | Concentration (mg/L) | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| Summer Sampling | | | | |
| North Toronto | | | | |
| N1406C1 | 5.0 | 5.2 | 0.20 | 4 |
| N1506C2 | 4.0 | 6.8 | 2.80 | 70 |
| N1606C3 | 2.0 | 4.4 | 2.40 | 120 |
| N1706C4 | 2.8 | 3.8 | 1.00 | 36 |
| Perth | | | | |
| P1309C1 | 4.6 | 4.2 | -0.40 | -9 |
| P1409C2 | 5.2 | 4.2 | -1.00 | -19 |
| P1509C3 | 6.2 | 4.1 | -2.10 | -34 |
| P1609C4 | 5.0 | 2.7 | -2.30 | -46 |
| P1309G1 | 5.0 | 5.0 | 0.00 | 0 |
| P1409G2 | 5.0 | 4.5 | -0.50 | -10 |
| P1509G3 | 6.0 | 4.0 | -2.00 | -33 |
| Stratford | | | | |
| S1207C1 | 14.0 | 14.0 | 0.00 | 0 |
| S1307C2 | 15.2 | 15.6 | 0.40 | 3 |
| S1407C3 | 16.0 | 14.8 | -1.20 | -7 |
| S1507C4 | 18.4 | 14.0 | -4.40 | -24 |
| Walkerton | | | | |
| W2106C1 | 0.1 | 0.6 | 0.47 | 392 |
| W2206C2 | 0.2 | 0.4 | 0.27 | 180 |
| W2306C3 | 0.2 | 0.4 | 0.22 | 122 |
| W2406C4 | 0.3 | 0.5 | 0.22 | 88 |
| Wallaceburg | | | | |
| G0609C1 | 9.0 | 12.2 | 3.20 | 36 |
| G0709C2 | 9.0 | 5.9 | -3.10 | -34 |
| G0809C3 | 6.4 | 4.3 | -2.10 | -33 |
| G0909C4 | 8.6 | 6.8 | -1.80 | -21 |
| G0609G1 | 7.0 | 9.8 | 2.80 | 40 |
| G0709G2 | 1.6 | 2.2 | 0.60 | 38 |
| G0809G3 | 9.0 | 4.4 | -4.60 | -51 |
| G0809G4 | 19.2 | 16.6 | -2.60 | -14 |
| G0809G5 | 6.4 | 7.0 | 0.60 | 9 |
| G0909G6 | 0.8 | 0.3 | -0.49 | -61 |

Table F.4 Effluent Ammonia Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | -----Concentration (mg/L)----- | | | Difference |
|---|---|---|---|---|
| | Field | Lab | Difference | as Percent of Initial |
| **Winter Sampling** | | | | |
| **Bracebridge** | | | | |
| B1212C1 | 0.4 | 0.3 | -0.09 | -24 |
| B1312C2 | 0.5 | 0.5 | 0.04 | 9 |
| B1412C3 | 0.6 | 0.5 | -0.07 | -13 |
| B1512C4 | 0.8 | 0.7 | -0.10 | -12 |
| **Highland Creek** | | | | |
| T2203C1 | 40.2 | 21.0 | -19.19 | -48 |
| T2303C2 | 36.3 | 23.0 | -13.33 | -37 |
| T2403C3 | 24.4 | 20.0 | -4.40 | -18 |
| T2503C4 | 22.0 | 22.0 | 0.04 | 0 |
| T2203G1 | 37.9 | 23.0 | -14.89 | -39 |
| T2303G2 | 38.0 | 23.0 | -14.96 | -39 |
| T2403G3 | 24.0 | 22.0 | -2.04 | -8 |
| T2503G4 | 20.7 | 23.0 | 2.26 | 11 |
| **Huntsville** | | | | |
| H0612C1 | 14.0 | 10.4 | -3.60 | -26 |
| H0712C2 | 12.8 | 9.6 | -3.20 | -25 |
| H0812C3 | 13.6 | 8.8 | -4.80 | -35 |
| H0912C4 | 12.0 | 7.8 | -4.20 | -35 |
| **Lindsay** | | | | |
| L2903C1 | 22.0 | 24.0 | 2.04 | 9 |
| L3003C2 | 17.3 | 18.0 | 0.70 | 4 |
| L3103C3 | 15.9 | 21.0 | 5.10 | 32 |
| L0104C4 | 14.6 | 15.0 | 0.40 | 3 |
| L2903G1 | 22.0 | 25.5 | 3.54 | 16 |
| L3003G2 | 17.6 | 23.0 | 5.40 | 31 |
| L3103G3 | 15.9 | 19.0 | 3.10 | 19 |
| **Midland** | | | | |
| M1001C1 | 12.0 | 8.6 | -3.40 | -28 |
| M1101C2 | 12.0 | 9.0 | -3.00 | -25 |
| M1201C3 | 8.0 | 9.4 | 1.40 | 18 |
| M1301C4 | 7.2 | 5.8 | -1.40 | -19 |
| M1001G1 | 6.8 | 8.8 | 2.00 | 29 |
| M1101G2 | 8.8 | 6.0 | -2.80 | -32 |
| M1201G3 | 6.0 | 7.4 | 1.40 | 23 |
| M1201G4 | 7.6 | 5.0 | -2.60 | -34 |
| M1201G5 | 8.0 | 6.2 | -1.80 | -23 |
| M1301G6 | 8.4 | 6.0 | -2.40 | -29 |

Table F.4 Effluent Ammonia Levels Measured at Time of Collection Relative to Those After Delivery to Toxicity Laboratory

| | -----Concentration (mg/L)----- | | | Difference as Percent of Initial |
|---|---|---|---|---|
| | Field | Lab | Difference | |
| Winter Sampling | | | | |
| North Toronto | | | | |
| N1503C1 | 6.5 | 5.2 | -1.30 | -20 |
| N1603C2 | 6.6 | 7.9 | 1.30 | 20 |
| N1703C3 | 6.6 | 5.3 | -1.30 | -20 |
| N1803C4 | 6.5 | 4.6 | -1.90 | -29 |
| Perth | | | | |
| P2102C1 | 11.6 | 10.2 | -1.40 | -12 |
| P2202C2 | 10.8 | 8.2 | -2.60 | -24 |
| P2302C3 | 12.8 | 9.8 | -3.00 | -23 |
| P2402C4 | 12.0 | 9.0 | -3.00 | -25 |
| P2102G1 | 11.6 | 9.2 | -2.40 | -21 |
| P2202G2 | 12.0 | 8.8 | -3.20 | -27 |
| P2302G3 | 13.2 | 10.2 | -3.00 | -23 |
| Stratford | | | | |
| S1402C1 | 7.6 | 6.8 | -0.80 | -11 |
| S1502C2 | 7.6 | 6.8 | -0.80 | -11 |
| S1602C3 | 9.2 | 8.8 | -0.40 | -4 |
| S1702C4 | 9.2 | 6.2 | -3.00 | -33 |
| Walkerton | | | | |
| W1701C1 | 0.9 | 0.8 | -0.12 | -13 |
| W1801C2 | 2.5 | 1.8 | -0.66 | -27 |
| W1901C3 | 1.3 | 1.0 | -0.30 | -23 |
| W2001C4 | 0.9 | 0.7 | -0.16 | -18 |
| Wallaceburg | | | | |
| G2401C1 | 16.0 | 12.4 | -3.60 | -23 |
| G2501C2 | 16.0 | 10.6 | -5.40 | -34 |
| G2601C3 | 19.2 | 14.8 | -4.40 | -23 |
| G2701C4 | 16.0 | 12.6 | -3.40 | -21 |
| G2401G1 | 14.4 | 9.4 | -5.00 | -35 |
| G2501G2 | 18.0 | 12.8 | -5.20 | -29 |
| G2601G3 | 12.4 | 9.0 | -3.40 | -27 |
| G2601G4 | 18.0 | 10.0 | -8.00 | -44 |
| G2601G5 | 16.0 | 9.2 | -6.80 | -43 |
| G2701G6 | 15.2 | 12.0 | -3.20 | -21 |